D I F T A

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Gear selectivity estimates for Danish Baltic and Kattegat fleets

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1. Introduction

DFU, DIFER and IFM are carrying out a 3 year project entitled "Systems for the regulation of fishing effort - possible applications in Danish fisheries" which aims to develop management methods based on the regulation of fishing inputs (effort) that can be used as alternatives to or supplement traditional output regulation methods (quota systems). Within this project DFU are seeking to develop a model which can describe a fleet's selectivity taking into account:-

- the target and by-catch species seasonal length distributions over different fishing grounds
- the fleets seasonal distribution of fishing effort over these different fishing grounds
- the fishing gear's size selectivity.

DFU have subcontracted DIFTA to produce estimates of the size selectivity of the gears used by the principal Danish fleets participating in the following three fisheries which have been chosen for study:-

- the Baltic cod fishery
- the fishery for demersal human consumption species in the Kattegat
- the North Sea fishery for industrial species.

The third fishery was disregarded as there is no effective size selection in small meshed industrial fishing gears. The principal target species in the Kattegat fishery are cod, sole, plaice and *Nephrops* and selectivity estimates were required for these four species and Baltic cod only.

Information was requested on which factors could affect the selectivity of the gears used in these fisheries and how fishermen might adjust their gear design and hence its selectivity in future. Data on the survival rates of fish escaping through codend meshes or discarded from the vessels deck were also reviewed in case these could be in some way incorporated in models of the fishing mortality imparted by these fleets.

2. Materials and methods

Estimates of fleet gear selectivity have been obtained by analysing measurements taken by research institutes on individual vessel trips with gears that are representative of those used in the commercial fleet. Such data on fishing gear selectivity are not currently systematically collected on national or international databases. The ICES FTFB working group wish to establish a data base and members are currently carrying out an EC financed Concerted Action that seeks to determine a specification, how and by whom it should be administered and the associated costs. At present data are basically only available in scientific papers and "grey literature" such as project reports.

Reviews of codend selectivity data have previously been carried out by DIFTA for the EC firstly in 1988 and then updated in 1991, Wileman 1988 and 1992. Selectivity parameter estimates for North Sea species and mean values for parameters known to have a significant effect upon selectivity were extracted from reports and entered onto spreadsheets. These data have not been updated since except those for *Nephrops* which were updated by the FTFB Working Group in April 1995, Anon 1995, using the same spreadsheet format. Selectivity data for Baltic cod in trawls were reviewed and summarised by the FTFB Working Group in April 1995 and April 1996, Anon 1995 and 1996. Gill net selectivity data obtained by EU research institutes were collected and reanalysed in a uniform way by DIFTA and IPIMAR, Lisbon, Portugal at the end of 1996 within an EC financed study coordinated by ConStat, Holst et al 1997. These reviews are the only current sources for collections of selectivity data.

Scientific papers and reports relating to towed gear selectivity produced since the 1991 review have been examined. The data produced in the reviews named above have been reassessed in the light of the following:-

- the codend covers used in all experiments prior to 1991 and many since were of an unsatisfactory design that can lead to masking of the codend meshes hindering the escape of fish, Wileman et al 1996.
- the ICES gauge used for measuring mesh size by research institutes produces a value approximately 4% lower that the legal EC wedge gauge with 5kg hanging weight used by fishery inspection officers.
- new improved models for analysing gear selectivity data have been developed since 1991.

Direct contact was made to the following institutes in order to obtain recent unpublished selectivity data:-

- Havsfiskelaboratoriet, Lysekil, Sweden.
- Institut für Fischereitechnik, Hamburg, Germany.
- The Marine Laboratory, Aberdeen, Scotland.
- The Fisheries Research Station, Oostende, Belgium

There were found to be several new data sets for Baltic cod and *Nephrops*. There were no data for Kattegat cod so it was decided that a comparison should be made of the data for cod in the neighbouring areas North Sea, Skagerrak and Baltic Sea.

Towed gear selectivity data for cod, plaice and *Nephrops* have been entered into Excel spreadsheets following the format currently proposed by the group carrying out the EC selectivity data base Study previously referred to. The required list of parameters known to affect selectivity and parameters describing the gear selectivity and their variance has been substantially increased since 1991. These spreadsheets are reproduced in Appendix 2 and the associated notation and references given in Appendix 1. There has been so little research made on towed gear selectivity for sole since 1991 that it was not judged worth reprocessing the large number of data sets produced in Wileman 1992 most of which are now very dated. The relevant data sheets from Wileman 1992 have been reproduced in Appendix 3.

The gillnet selectivity data is summarised in Appendix 4.

Only simple analyses of the selectivity data have been made in this report. Most of the data is summarised by experimental test case i.e. vessel-gear-trials period. A few data sets result from analyses carried out over several gears or trials periods.

For towed gears averages, 95% confidence limits, maximum value and minimum value have been determined for the selectivity parameters from the estimated mean values for each experiment for a given fleet, gear and codend type. There is a wide variation in the number of hauls carried out per experiment so average values weighted by the number of hauls and the square root of the number of hauls have also been computed. When last reviewing a set of codend selectivity data the ICES FTFB working group elected to weight by the square root of the number of hauls, Anon 1996, so these values have been chosen. Linear regressions have been used to determine if the mean values of selectivity parameters are dependant upon mesh size or vessel HP.

For gillnets there are far fewer data sets (maximum 5) for a species. Mean values for the selectivity parameters have been calculated weighting by the total numbers of fish caught in particular length ranges.

It is emphasised that these procedures will only give a very rough approximation to the mean value for a fleet selectivity parameter and any quoted 95% confidence limits are in no way a true measure of the total variability in the data. Most authors have either not reported the within experiment estimated variance of the selectivity parameters in full or have estimated it incorrectly so it is impossible to take this into account.

Proper estimates of the confidence limits of the fleet selectivity parameter values can in fact only readily be obtained from the above data, summarised by experiment, in the unlikely event of all data sets having been analysed using the same selectivity curve model and Fryer's model of between-haul variation, Fryer 1991. Haul to haul variability can be relatively high and needs to be taken into account. Data sets where catch data have not been analysed using the same chosen selectivity curve and Fryer's model of between-haul variation, would have to be re-analysed from the haul by haul catch data. A "random and fixed effects" model of the type also developed by Fryer could then be fitted which can describe the effect on selectivity of explanatory variables such as mesh size and vessel size, take into account the effects of between-haul and between-vessel trip variation, give improved estimates of the fleet selectivity parameters and representative values for their confidence limits, Fryer 1996.

3. Variability of gear selectivity estimates

3.1 Towed gears

3.1.1 Selectivity parameters

The selectivity of a towed gear is usually only measured in the codend where underwater observations show that a substantial part of the selection takes place. Size selection also takes part in other parts of the gear e.g. over the bridles and under the footrope / bobbins but estimates of whole gear selectivity have only been made for stock survey gears.

The logistic curve is the model usually used to describe the S shaped selectivity curve for a towed gear but other parametric and non-parametric forms are sometimes found to give superior fits to the catch data and are used instead, see Wileman et al 1996. The curve is therefore generally characterised by specifying the **50% retention length** or **L50** (length of fish that has a 50% chance of being retained) and the **selection range SRange** = L75-L25. It is normally found that if testing several different codend meshes that L50 is approximately directly proportional to mesh size so the **selection factor SF** = L50 cm *10 / mesh size mm is also calculated. Some authors have suggested that SRange should also be directly proportional to mesh size and the **selection ratio SRatio** = SRange cm * 10 / mesh size mm is therefore sometimes calculated.

When examining the variability in a gear's selectivity or comparing the selectivity of two different gears it normally appears to be easier to determine significant differences in L50 or SF than SRange which often exhibits a lot of unexplained between haul variability. When modelling changes to selectivity generated by changes in factors such as catch weight, weather or codend specification it is usually found that assuming L50 changes but SRange is unchanged gives an acceptable fit to the data if changes in mesh size are not very large. Haddock is the species for which the highest number of selectivity measurements have been taken. Page A2-38 in Appendix 2 summarises recently obtained estimates of SRange for different codend mesh sizes. There is a large amount of scatter but it seems that SRange does increase with mesh size and that it would be more appropriate to assume that SRatio was constant than that SRange was constant for the wide range of mesh sizes tested with this species. Assuming that SRatio is constant is therefore probably the better general model.

3.1.2 Overall variation for a species

Examination of the collections of selectivity measurements for roundfish contained in Wileman 1992 shows that the selection factor for an individual experimental case (vessel - gear - codend - trip) can vary by quite large amounts (30-60%) from the mean value for all such measurements. This does not, however, appear to be the case for flatfish as shown in the following table:-

			Selection Factor				
Species	Fishing Method	Data sets	Mean	within +/-10%	within +/-20%	Min value	Max value
Cod	Otter Trawl	28	2.99	17	21	1.67	4.11
Haddock	Otter Trawl	63	3.09	24	39	1.31	4.39
Whiting	Otter Trawl	72	3.53	30	54	2.11	4.82
Sole	Beam Trawl	57	3.23	54	57	2.74	3.56
Plaice	Beam Trawl	14	2.17	12	14	1.83	2.37

3.1.3 Effect of test method

There are 5 basic approved techniques for measuring codend selectivity: covered codend, twin trawl, trouser trawl, alternate haul and parallel haul, Wileman et al 1996. The covered codend is most popular as it requires fewer hauls to obtain satisfactory parameter estimates.

No satisfactory direct comparisons of these techniques have been made at sea.

It is well documented that even with moderate catches a cover can mask the codend meshes unless hoops or other devices are fitted to the cover to hold it clear of the codend catch, Main and Sangster 1988. Use of hoops with covers first became widespread in 1991 and measurements taken using the covered codend technique before this date have to be regarded as suspect. In a documented direct comparison of using covers with and without hoops on identical codends in a twin trawl system, Main et al 1992, it was found that L50s for haddock and whiting were reduced by 7-18% when using a cover without hoops. Comparison of Scottish pre and post1991 haddock and whiting selection factor estimates suggests that in some cases the reduction has been well over 30%. Masking of the codend by the cover in the event of large catches is without doubt the cause of the very low minimum selection factor estimates for roundfish shown in table 1. Hoops were originally made of 2-2.5m diameter and fitted externally to the cover being attached by rings. It was then found that test codends of large mesh size over 100mm and 100 open meshes could have a diameter of over 2.5m with large catches. This led to the use of 3m hoops fitted internally to the cover which give severe handling problems on deck.

The Fisheries Research Station, Oostende has made comparisons of using the covered codend and twin trawl technique for measuring beam trawl codend selectivity for sole. Fonteyne 1988 reported reductions in SF of 11% and 6% when using a codend cover with floats as opposed to the twin trawl technique but in a later experiment, Fonteyne 1991, in fact obtained a 3% higher SF with the cover technique. Polet 1994 obtained an extremely high SF estimate of 3.8 when using the twin trawl technique as opposed to 3.4 (11% less) when using a cover fitted with steel hoops. It appears that flatfish escape can also be affected by the masking effect of covers and even when hoops are fitted.

Several experienced gear technologists and fish behaviour researchers maintain that even if hoops avoid the masking problem, that fish escape will still be reduced due to the effect of the cover on water flow in the codend.

3.1.4 Variability between hauls

A towed gear's selectivity can be found to have quite large haul to haul variability. Variation in L50 is sometimes within 5% of the mean value but hauls with L50 departing from the mean by 30% can be found in some experiments. Changes in the fishing conditions (grounds, catch size and weather) are thought to be mainly responsible.

In some cases total catch weight has been found to affect L50 by up to 10%. It appears to be a complicated non-linear effect with L50 increasing as catch weight increases to about 500kg then remaining constant or possibly decreasing with catch weight for very large catches, O'Neill and Kynoch 1996. In one set of trials measuring nephrops selectivity, Polet and Redant 1994, changes in sea state caused 20% deviations from the mean L50 (L50 increased with sea state). Significant differences can also be found between L50 measurements taken on groups of hauls made on different grounds within the same trip e.g. Lowry 1997. This is presumably linked to differences in fish condition or behaviour.

This haul to haul variability has to be taken into account if confidence limits are to be given for a measurement of gear selectivity in a particular case.

3.1.5 Variability between trips

Clearly changes in the mean fishing conditions can cause variations between trips in L50 for a given vessel, gear and codend. In addition seasonal changes in fish condition appear to have a substantial effect upon selection.

In recent trials, Ozbilgin 1997, conducted by the Marine Laboratory, Aberdeen carried out with the same vessel, gear, codend and grounds at 3 different times of the year (February, April and September), the estimated L50s and SFs for Haddock for each season-trip were found to be significantly different:-

- February - pre-spawning L50 = 31.21cm SF = 3.16
- April - post-spawning L50 = 27.65cm SF = 2.69
- September- well fed L50 = 33.36cm SF = 3.39

giving variations from the overall mean by up to 13%. Differences in L50 and SF did not correspond to the measured differences in haddock girth (escape was lowest when the fish were thin!!), suggesting that the differences are due to changes in fish behaviour or swimming ability rather than physical dimensions.

In a similar experiment on Baltic cod conducted by IMR, Sweden, Tschernij et al 1996, the estimated L50s and SFs were:-

- December - L50 = 35.1cm SF = 2.85
- March - L50 = 30.5 cm SF = 2.48 (significantly different)
- June - L50 = 35.3cm SF = 2.87

3.1.6 Effect of codend parameters

As already mentioned **mesh size** has the main effect with L50 being approximately proportional to mesh size. It should be noted that the mesh size measurements obtained on trials are dependent upon the type of gauge used. Most research institutes use the ICES gauge at 4 kg loading. For mesh assessments mesh sizes should be as measured by the legal gauge used by fishery inspection officers (wedge gauge with 5kg hanging weight). The ICES gauge underestimates the legal mesh size by about 3-4%, Ferro and Xu 1996, and therefore mesh sizes measured in experiments require correction.

The **number of open meshes round the codend circumference** (excluding the meshes in the selvedges) affects L50 for demersal roundfish, Galbraith et al 1994. In the North Sea this number is restricted to a maximum of 100. Smaller vessels can use as low a number as 70 which is predicted to increase L50 for roundfish by 15%-20%.

The **total length of the codend** (including extension pieces) has also been found to affect L50 for demersal roundfish. Increasing length consistently decreased L50. Unfortunately all but one of the experiments made investigating this effect used covers without hoops so the change cannot be safely quantified. It is thought that the effect is relatively small.

The **twine thickness** of the codend affects L50 for demersal roundfish. Recent Danish and Norwegian tests, Lowry et al 1997, show that increasing or decreasing thickness compared to the normal commercial twine can change L50 by up to 10%. Reducing thickness increases L50.

3.1.7 Effect of vessel and gear size

Codend circumference, length and twine thickness can be expected to increase with vessel size and thereby decrease L50 for roundfish. No controlled tests seem to yet have been made measuring the codend selectivity for different sizes of vessel fishing together on the same stock using identical codends and the same experimental technique. Larger vessels can be expected to have larger catches which should affect selectivity. German tests where 2 different sizes of trawl were used with the same codend on a research vessel gave no significant difference in L50, Dahm et al 1997.

3.1.8 Effect of fishing method

Beam trawls, otter trawls, pair trawls, pair seines, Scottish seines and Danish anchor seines are all used to catch demersal species. No controlled experiments have been made where the selectivity of two different towed gear fishing methods is directly compared. Simple statistical analyses of the overall selection factor estimates for individual experiments, Wileman 1992, and a recent review by the Marine Laboratory, Aberdeen, Ferro 1996, both suggested that differences between gear types were not significant (cannot be distinguished from variations between vessel trips for the same fishing method).

3.1.9 Implications for determining a fleet's codend selectivity

1. Selectivity measurements need to be available for a large number of cases (vessel-gear-codend-season)
2. These should in particular cover different sizes of vessel (in order to cover the range of codend twine thickness and overall dimensions) and different seasons.
3. If there is limited selectivity data then it will probably be acceptable to pool data for a species over different types of towed gear and neighbouring fishing areas / fish stocks.
4. Pre 1991 covered codend data should not be used unless it was or can be shown that selectivity was not affected by the cover.

3.2 Gill nets

3.2.1 Selectivity parameters

Gill net selectivity is principally dependant upon mesh size. It is normally assumed that retention lengths are directly proportional to mesh size (Baranov's widely accepted law of similarity, Baranov 1948). Selectivity curves are dome shaped and characterised by 3 or more parameters the most important of which is the modal length (length that gives highest retention probability) to mesh size ratio or **modal value**, Hamley 1975. Gill net selectivity is estimated by fishing together in a fleet of nets four or more different mesh sizes. An indirect estimate of relative selectivity is obtained. The relative length distribution of the population encountering the nets is simultaneously estimated. The absolute numbers of fish encountering the nets cannot be estimated.

The gill net selectivity models to be used here derive from a recent DIFTA - SEAFISH - IFREMER - DIFRES AIR project, Anon 1997. They are based on fish being principally caught by two catch processes - enmeshing and entangling. Entangling is assumed to be a constant probability for fish under modal length and a second different constant for fish above modal length. Enmeshing is the main catch process and modelled by the ascending half of a scaled normal distribution with maximum value at the modal length followed by the descending half of the same normal distribution scaled differently (such that the total relative selectivity at modal length = 1.0). The models have the four following parameters:-

- *k* the **modal value** = modal length to mesh size ratio
- *st* the spread or standard deviation of the normal distribution prior to scaling
- *C1* the probability of fish under modal length being caught by random entangling
- *C2* the probability of fish above modal length being caught by random entangling.

The general mathematical form of the models is given later in section 5.2.

3.2.2 Overall variation for a species

There are relatively few gill net selectivity measurements for European marine species. The best derive from the AIR project, Anon 1997, referred to above. Modal values for the same species seem to only vary by up to 8% from the mean value for all cases (vessel - gear - stock - trip).

3.2.3 Variability between sets (hauls)

This has not been studied to date.

3.2.4 Variability between trips

In the AIR project variations in modal values were within 5% of the mean value for all trips with the same gear. Differences did not correspond well to the measured (seasonal) differences in girth.

3.2.5 Effect of gear type

It is thought that retention probability for fish above modal value should be higher in trammels than gill nets for fish above modal value. In the AIR project there was some evidence of this for cod and sole but not for plaice.

3.2.6 Effect of net design parameters

There are several papers reporting experiments that show that **hanging ratio** can affect a gill net's selectivity. At present there are no measurements quantifying the effect on the size selectivity of European marine species but Swedish experiments on Baltic cod will be conducted in 1997/8.

It is claimed in reviews of gill net selectivity that other parameters such as twine material, thickness and colour can affect size selectivity but it is thought that such parameters will principally affect efficiency/catching power. Danish experiments on Baltic cod will be conducted in 1997/8 to determine the effect of twine thickness.

3.2.7 Effect of vessel size

It is thought that vessel size should have little effect on size selectivity of gill nets but there are no measurements to back this up.

3.2.8 Effect of method of data analysis

Researchers have used several different models for the selectivity curve. Decision on which model to use is often made very arbitrarily. The estimated selectivity is highly dependant on the model chosen. In the AIR project it was found that modal values could be underestimated by up to 13% if using a simple traditional normal distribution model.

3.2.9 Implications for determining a gill net fleet's selectivity

1. Selectivity data for different stocks / fishing areas can be combined for a species.
2. If possible data for gill nets and trammels should be segregated and an examination made to see if differences are significant.
3. An evaluation has to be made of whether data sets should be included if the hanging ratio for the experimental nets lies outside the range of values used in the commercial fleet.
4. It may be necessary to reject cases where an unsatisfactory model was used for gill net selectivity.

4. Individual gear selectivity measurements

4.1 Towed gears

4.1.1 Baltic Cod

The data are to be found in Appendix 2 pages A2-1 to A2-18. Only demersal bottom trawls have been tested. The results of new German tests have been added to the data reviewed by the ICES working group in 1996. Data from Russian and Polish trials has been excluded due to the use of inappropriate experimental methods. The data therefore derive from Danish, Swedish and German vessels and are of good quality as modern experimental methods and data analysis techniques have been used throughout.

Four different types of codend have been used:-
- standard codends made totally in conventional diamond meshes
- "Swedish" window codends which have panels of specially impregnated stiff nylon netting of a given mesh size inserted in the sides (where the selvedges would normally be) of 105mm diamond mesh size codends and hung in such a way that the meshes remain wide open. This design is specified in the Fishery Rules of the International Baltic Sea Fishery Commission (termed exit window model 1).
- "Danish" window codends which have square mesh panels of a given mesh size inserted in the sides of 105mm diamond mesh size codends immediately below the selvedges (i.e. in the lower half of the codend) as prescribed in the Fishery Rules of the International Baltic Sea Fishery Commission (termed exit window model 2).
- "German" window codends which have square mesh panels of a given mesh size inserted between the selvedges at the front end of the upper panel of 105mm diamond mesh codends. This is the type of square mesh panel permitted under EU legislation in other fishing areas (developed and principally used in the UK and Ireland).

Standard codends
There are 13 data sets from 6 vessels only one of which is Danish. Nominal mesh sizes between 105mm and 140mm have been used. Inspection of the scatter plots and linear regressions shown on pages A2-4 and A2-5 reveals that there are large variations in L50 for similar mesh sizes that do not correlate to changes in vessel HP or season. It seems to be reasonable to treat L50 and SRange as being directly proportional to mesh size (see pages A2-4 and 6). From page A2-3 it can be seen that adopting a procedure of weighting by the square root of the number of hauls gives a mean SF of 2.97 and SRatio of 0.73.

Swedish windows
There are 6 data sets from 2 Swedish vessels of rather large horse-power. 3 different mesh sizes 97,103 and 117mm have been used for the windows. The selectivity in window codends is often rather difficult to evaluate as selection can occur both through the windows and through the normal 105mm codend sections. The selectivity curve is not always adequately modelled by the logistic function and non-parametric curves have been fitted. Unfortunately the selectivity of window codends were not directly compared with equivalent standard codends. It can be seen on page A2-9 that in the limited experiments conducted that L50 has clearly increased with window mesh size indicating that a substantial part of the selection did occur through the windows. From

the linear regression of L50 against window mesh size it seems that the two are directly proportional and it would be appropriate to base a selection factor on window mesh size. Weighted mean selection factor based on window mesh size is 3.53, 19% higher than that for the conventional codend. There are large variations in SRange, 5.4 to 8.2cm which do not correlate to changes in window mesh size. Mean SRatio is 0.63 if based on either window or codend mesh size.

Danish and German windows
Danish windows have basically just been tested on one Danish vessel of 290HP. There was a significant increase in L50 with window mesh size for the 3 mesh sizes (107mm, 116mm and 121mm) tested on the first trip, from 32.7cm to 38.3cm. Codend catch weights were high. Direct comparisons were made with a standard codend, there was only a slight (0.9cm) but significant increase in L50 for the 107mm window. On the second trip, carried out in the same month the following year using a different trawl but same basic codend specification, only a 115mm window was tested and the estimated L50 of 32.6cm was 10% lower than that obtained on the first trip (36.1cm with the 116mm window). It appears that the main part of the selection occurred through the window in the first trip but in the second either there was little escape through the window or gear selectivity had been very low due to some other factor such as fish condition. In addition there are measurements from a single haul on a German vessel.

German windows have been tested on one Swedish and three German vessels. The L50 was very high on the Swedish vessel trip but no comparison was made with a corresponding standard codend. On the first German trip inserting a 114mm window produced an estimated increase in L50 of only 1.1cm compared to a corresponding standard 109mm mesh codend. In the second and third trips carried out simultaneously on two vessels three different window mesh sizes (108mm, 112mm and 121mm) were tested. There was no significant increase in L50 with window mesh size on either vessel. A standard codend was also tested on one vessel. The L50 was 1-2cm less but the difference was not significant. It appears that there could have been very limited escape of fish through these windows on the German trips but a selection factor based on the codend mesh size has a mean value of 3.27, page A2-14, about 10% higher than the overall mean for standard codends.

Comparison of the summary tables on pages A2-13 and A2-14 shows that there are no significant differences in the selectivity parameters for these two types of codend (when basing SF and SRatio on window mesh size). The 95% confidence intervals overlap and if the effects of between haul variation were included the confidence ranges would expand. The data for the two codend types have therefore been pooled giving 13 data sets from 5 vessels.

The estimated mean L50 for a 107mm mesh size standard codend is 31.8cm. The scatter plot on page A2-16a shows that for these window codends the estimated L50 was in some cases much higher but on other occasions only marginally higher and that there is a poor overall correlation between L50 and window mesh size. The weighted mean for SF is 3.05 (much lower than that of the Swedish window) if based on the window mesh size. Basing SF on window mesh size does not seem to be very appropriate, however, if the main part of the selection does not always occur through the windows. Basing selectivity parameters on the mean of the window and codend mesh sizes is a suggested compromise giving weighted means of 3.15 for SF and 0.69 for SRatio.

It had been suggested that because these windows do not extend beyond the lifting strop into the final 2m of the codend, whereas the Swedish windows do, these windows will only work well in the case of high catches. The scatter plot on page A2-17 shows that the lowest values of SF did occur for catches of under 600kg but that there were also just as many high SF values for these catch weights. Catch weight does not seem to be a critical factor but location of the windows almost certainly is. Recent comparative fishing tests carried out within the EC FAIR project BACOMA have shown that locating the windows behind the lifting strop increases the release of small cod.

4.1.2 Kattegat Cod

As previously mentioned no measurements have been made of the selectivity of cod in this area.

4.1.3 North Sea Cod

There are 13 recent good quality data sets from 4 vessels fishing in the North Sea or adjacent Skagerrak. Specifications of the codends used are similar to those for Baltic cod. It can be seen from the data summary sheet page A2-21 that the weighted mean SF is 3.31 and appears to be significantly different (11% higher) to that for Baltic cod which have a different body shape being relatively larger headed and thinner bodied. The weighted mean SRatio is 0.62.

4.1.4 Sole

The only selectivity data available for sole are for beam trawlers in the North Sea. These are to be found in Appendix 3 pages A3-1 to A3-10. A new summary table, page A3-11, has been produced after omission of two of the data sets where there were few fish in the selection range and after correction of the mesh sizes to wedge gauge equivalents. There are 53 data sets from 10 vessels and a wide range of different codend mesh sizes (64 to 105mm). Most data sets were obtained using a codend cover without hoops and the others using the twin trawl technique (labelled P for parallel haul in the data sheets). It was found that the SF values for the covered codend tests are in fact higher that those for the twin trawl tests so there is no justification for rejecting the former.

L50 is well correlated to mesh size, see page A3-12, with a mean SF of 3.11. There are signs of possible seasonal effects with SF being low in spring (post spawning?) and high in summer, see page A3-13. Selection range is not well correlated to mesh size, see page A3-14, and has a mean value of 4.0cm. SRatio has a mean value of 0.48 but appears to exhibit higher variability than SRange.

4.1.5 Plaice

No selectivity measurements have been obtained since the review of Wileman 1992. Data are of poor quality throughout and only available for the North Sea and the adjacent part of the Skagerrak. Examination of these data sets revealed that many should be rejected for one of the following reasons:-

- there were too few fish in the selection range

- the trouser trawl technique had been used and there was estimated to be a large difference in numbers of fish entering the test and small mesh codends
- the author had been unable to estimate the SRange (or had failed to report it)
- the data were extremely old circa 1960.

There remain 11 data sets for codend mesh sizes between 94mm and 143mm obtained on two Dutch beam trawlers using unhooped covers and one Danish anchor seiner when the trouser trawl technique was used, pages A2-22 and 23. There was good correlation between L50 and mesh size for the beam trawlers. The estimated SF values are approximately 2.0 and 2.2 for the beam trawlers and 2.7 for the anchor seiner, see pages A2-22 to A2-25. The rejected data sets had estimated SF values in the range 1.9 to 2.4. It seems unlikely that there were serious codend masking problems on all experiments when covers were used. It does not seem to be reasonable to assume that anchor seiners have abnormally high SF values for plaice on the basis of a single trips results. Weighted mean SF for the 3 vessels is 2.19. There is poor correlation between SRange and codend mesh size. Mean SRange is 3.9cm and mean SRatio 0.33.

4.1.6 Nephrops

Standard and window codends

There are 18 data sets for standard codends, pages A2-27 and 28. The first 9 data sets refer to a matrix experiment where 3 different codend circumferences were tested each in 3 different mesh sizes and a model developed describing the effect of these two variables on the selectivity parameters. In the analysis these were reduced to 3 data sets one for each mesh size at the conventional commercial circumference of 100 open meshes. In addition there are 2 data sets for codends fitted with a square mesh panel window designed to allow immature whitefish to escape, page A2-29. These window codends have been found to have no effect upon *Nephrops* selection and are therefore included with the standard codend data.

Four different experimental techniques have been used covered codend, twin trawl system to measure codend selectivity, twin trawl system to measure whole trawl selectivity (where all parts of one trawl are made in small mesh, data base reference 25) and in one case (data base reference 27) no small mesh codend or cover was used but the selectivity curve was fitted to the catch data of 7 Danish vessels using twin trawl systems to compare catches in 60mm and 70mm codends (obtaining indirect estimates of selectivity as is the practice in gill net fisheries).

Whole trawl selectivity

Hillis and Earley 1982 conducted an experiment that demonstrated that *Nephrops* can escape in substantial numbers in the main body of the trawl as well as the codend. Lehmann 1993, carried out measurements of codend selectivity using a twin trawl rig with hooped covers on each codend. One trawl body was made in 110mm full mesh size and the other was in 80mm full mesh size. The combined cover and codend catch numbers of *Nephrops* of small length classes were higher in the 80mm trawl confirming that selection also took place in the trawl body.

The only available estimates of full trawl nephrops selectivity derive from a single trip on a Scottish vessel testing a trawl with 70mm full mesh body and two different codend mesh sizes

69mm and 81mm. L50 was not significantly increased when the larger mesh codend was used. The estimated SRanges are very different for the two codend cases and much lower than in all other experiments where only codend selectivity was measured. SF was 0.35 for the 69mm codend case.

Codend selectivity

There are 12 data sets from 11 vessels. No data sets have been obtained exclusively in the Kattegat but in two (data base references 22 and 27) fishing was carried out in the Skagerrak and Kattegat. A wide range of mesh sizes 60-111mm have been tested. There is poor correlation between L50 and codend mesh size, see page A2-31. Mean weighted SF is 0.41. There is lot of variation in SF particularly for mesh sizes of 60 to 80mm and no obvious dependence upon vessel size or season. *Nephrops* trawls often have a tendency on some grounds to collect large quantities of mud and bottom rubbish. This has been reported in some of the experiments and could well be the cause of low estimates of SF under 0.4. It is difficult to judge whether there has been a genuine change in codend selectivity or if the performance of the small mesh cover/codend has been affected.

Selection range seems to be well correlated to mesh size, see page A2-33. Mean SRatio is 0.20.

Square mesh codends

These have principally been tested in Sweden with a view to obtaining codends with reduced selection range. There are 6 data sets for mesh sizes of 51 to 66mm, page A2-34. There are few data so correlation between selectivity parameters and mesh size is not surprisingly poor. Direct comparisons have not been made with corresponding standard codends. Mean SF should be higher than for convention diamond mesh netting and is at 0.53 but there are too few data sets for the difference to be significant. Mean SRatio is 0.21.

4.2 Gill nets

4.2.1 Baltic cod

Measurements have been obtained by the Institut fur Fischereitechnik, Hamburg, Germany within an EC funded Study completed in April 1997. A copy of the results has been requested but not yet received.

A comparative fishing exercise testing gill net mesh sizes of 105mm, 110mm, 120mm and 130mm was conducted by DIFTA in conjunction with the Danish fishermen's association in autumn 1993, Lowry et al 1994. The different mesh sizes were not fished together in the same fleets and there some differences in design between the nets. Attempts to fit selectivity curves were unsuccessful. Catches in the different mesh sizes peaked at cod length to mesh size ratios of 4.1 to 4.2 which should approximate to the modal value k.

DIFTA and the Marine Institute, Sweden are to obtain selectivity measurements in autumn 1997.

4.2.2 Kattegat cod

No measurements of gill net selectivity for cod have yet been obtained in this area.

4.2.3 North Sea cod

Four data sets are available all deriving from Anon 1997 and summarised in Appendix 4 pages A4-1 to A4-5. All trials in this project were made on commercial vessels using a range of mesh sizes that started at or below the minimum value used in the fishery and extended up to or beyond the mesh size usually used on the trials vessel. The first data set is for slackly hung Danish multimono cod gillnets (floatline hanging ratio 0.38). The selectivity curve was fitted to the catch data from 4 trials periods (without pooling catches from the different trials). Modal length to mesh size ratio ***k*** was approximately 4.2 in the two spring trials (post spawning) and approximately 4.5 in the two late autumn trials indicating a seasonal variation. Bycatches of cod in the Danish trials with slackly hung multimono sole gillnets (floatline hanging ratio 0.27) and multimono plaice trammels (hanging ratio on the floatline 0.38) were large enough to allow estimation of the selectivity parameters after pooling across all trials periods. The fourth data set is from an English vessel using multifilament trammels (floatline hanging ratio 0.5) for 7 short trips in the winter months.

The main catching process was found to be enmeshing behind the gill covers. The two parameters associated with this ***k*** and ***st*** were reasonably constant between data sets as was the parameter ***C1*** modelling the random entangling of small fish, see page A4-5. There appears to be a difference between gillnets and trammels with trammels entangling more large fish well above modal length (higher ***C2***).

No attempt was made within the project to fit a general selectivity curve simultaneously across the four different gears. The following procedure was adopted for producing weighted mean values of the selectivity parameters. The numbers of cod have been calculated whose transformed length was less than ***k-2*st***. They lay below the lengths primarily caught by gilling and therefore determine the accuracy with which ***C1*** can be predicted. Similarly cod above ***k+2*st*** determine the accuracy of ***C2*** estimates. The remainder principally determine ***k*** and ***st***. Mean values for the selectivity parameters for gillnets and trammels were determined by weighting by these 3 different numbers of fish. The results are shown on page A4-5. Modal value is approximately 4.4, small fish have an estimated 8% relative probability of being entangled and large cod a 22% chance of being entangled in gillnets but a 55% chance of being entangled in trammels.

4.2.4 Sole

Five data sets are available from Anon 1997, 3 derive from a Danish vessel fishing in the North sea, one from an English vessel fishing in the Channel and one from a French vessel fishing in both the southern North Sea and the Channel. The 3 Danish data sets derive from a single long trials period with sole gill nets and the pooled bycatches taken in the cod gillnet and plaice trammel trials periods. The English data set is for multimono trammels (hung at 0.5) and the French for multifilament trammels (hung at 0.4). The selectivity parameter estimates are remarkably similar for the different areas and gear types with the exception of that describing the entangling of large sole ***C2***, see page A4-6. The numbers of very large sole caught were very low for the two Danish bycatches and the English trammels so ***C2*** estimates are unreliable for these three cases. At maximum probability of capture a mesh was caught on a head protrusion then stretched diagonally across the body. Weighted means were calculated as for cod. Mean estimated modal value is 3.25, the probability of entangling is 3-4% for small sole 22% for large sole in gillnets and 51% for large sole in trammels.

4.2.5 *Plaice*

Data sets were obtained on all three sets of gears tested on the Danish vessel, Anon 1997, plaice trammels, sole gill nets and cod gillnets all in multimono twine. Again the parameter estimates are very similar for all three gears, see page A4-7. Modal value was approximately 2.5 and corresponded to the situation where a mesh was caught on the anal fin spine then stretched diagonally across the body. Probability of entangling was found to be insignificant for small plaice and approximately 15% for large plaice in both trammels and gill nets.

5. Fleet gear selectivity models

5.1 Baltic cod trawlers and anchor seiners

5.1.1 Current gears and future possible developments

Legislation
Prior to 1 June 1995 the stipulated minimum mesh size was 105mm. After that date vessels had to use one of the three following options:-
- a standard codend with 120mm minimum mesh size
- a Swedish window codend with 105mm minimum mesh size in the windows and the rest of the codend
- a Danish window codend with 105mm minimum mesh size in the windows and the rest of the codend.

The aim of the new legislation was to achieve an L50 of 38cm but allow fishermen flexibility in the type of gear used, in particular to allow them to continue using trawls made in 110mm mesh throughout.

There are no restrictions on other codend parameters such as number of meshes round the codend or twine thickness.

Current codend specification
It is thought that all Danish vessels used standard codends of 105-110mm mesh size prior to 1 June 1995 and that they now use Danish window codends of 105-110mm (107mm would be a typical measured mesh size giving a small safety margin). The Swedish windows are not used because of the higher purchase price. A codend of 100 meshes round including the selvedges, giving 84 to 96 open meshes, made of 4mm double braided PET is a fairly standard specification (and that used on most gear selectivity trials). The codend itself would typically be 6m long. Codend extensions would be fitted on most vessels particularly the larger ones. Some small vessels may elect to use a thinner twine and some vessels may use thin twine for the codend and then fit a heavy Polish chafer (strengthening bag in twice the mesh size) in double braided PET.

Future possible developments
There is a stated biological aim in this fishery of achieving an L50 of 38cm. Using the mean SF derived in section 4.1.1 it would appear that the mesh size in standard codends may have to be increased slightly to 125mm or 130mm to achieve this.

The 105mm minimum mesh size stipulated for the Swedish windows appears to be satisfactory (108mm is the actual estimated required mesh size for an L50 of 38cm).

The 105mm minimum mesh size stipulated for the Danish windows is clearly too small and would have to be increased to about 125mm to give the required L50 (with 105mm mesh size in the rest of the codend). It is understood that the Baltic fishery rules are to be reviewed this year. There must be a risk that the Danish window option is removed totally such that fishermen have to use either the standard codend or the Swedish window.

The German Research institute has been keen to promote the possible use of traditional square mesh panels- here termed German windows. Interest may have waned because of the poor results given in their latest sea trials. On the other hand the latest long term proposals from the EC for northern areas under its jurisdiction are to require that square mesh panels of this type should be fitted to all otter trawls and seines having a codend mesh size over 70mm with the panel mesh size being at least as large as the codend mesh size. There may be a desire to have the same requirement in the Baltic in order to have uniformity of legislation. The long term minimum requirement might be for all gears to be fitted with either Swedish window codends with at least 105mm throughout or German/Danish window codends in 120mm throughout.

There may well be the requirement that codends should have a maximum of 100 open meshes round the circumference (as in the North Sea). This would have little effect as most if not all codends currently used would conform to this.

5.1.2 Cod model

As most data sets have been fitted with the logistic selectivity curve it is recommended that this be used. For gears and species tested over a wide range of different mesh sizes it appears to be reasonable to assume that L50 and SRange are directly proportional to mesh size. The model for retention probability r of a Baltic cod of length l cm is then:-

$$r(l) = \exp(a + bl) / (1 + \exp(a + bl))$$

where b = **SRange** cm / **2.197** = **SRatio * mesh size** mm / **21.97**
and a = **-L50** cm * b = **-SF * mesh size** mm *b/ **10**

For the different types of codend used in the fishery the appropriate estimated values of SF and SRatio are:-

Codend type	Reference mesh size	SF	SRatio
Standard	Codend	2.97	0.76
Swedish window	Window	3.53	0.63
Danish or German Window	Mean of Window+Codend	3.15	0.69

5.2 Baltic cod gillnetters

5.2.1 Current gears and future possible developments

Legislation
A minimum mesh size of 105mm is stipulated.

Current gear specifications
A limited gear survey was recently carried by DIFTA, as part of an EC financed study, in which 7 skippers were interviewed. All skippers used conventional gill nets as opposed to trammels. Mesh sizes range between 105mm and 200mm with a mean of 130mm. Hanging ratio is 0.5 on the

floatline and typically 0.57 on the sinkline. Multimono twine is used. Twine strength increases with mesh size (from 1.5*4 to 1.5*10).

Possible future developments
With a minimum mesh size of 105mm gillnet fishermen seem to target cod well above 38cm, Lowry et al 1994, and minimum mesh increases are not as likely as in towed gear fisheries. The majority of fishermen have been using mesh sizes above 120mm in recent years. Fishermen will probably match their mesh size to the availability and market price of different sizes of cod, decreasing mesh size in years with poor availability of large cod.

5.2.2 Cod model

Awaiting results from Germany

5.3 Kattegat *Nephrops* trawlers

5.3.1 Current gears and future possible developments

Legislation
The current minimum mesh size is 70mm and there are no special restrictions on other codend parameters.

Current gear specifications
Most vessels use twin trawl systems. In Denmark fishermen either use trawls made specifically for *Nephrops* and have the main body in 80mm full mesh or dual-purpose trawls that can be used either for whitefish or *Nephrops* and have a 110mm full mesh body. It is thought that the 80mm trawls dominate in the Kattegat and that fishermen always use 70mm codends (fishermen will use 100mm codends for mixed *Nephrops* and whitefish fishing in the North Sea and Skagerrak). It is understood that there has been a general trend to change from soft nylon codend twine to thicker double braided PET twines since the mesh size increase from 60mm to 70mm.

Possible future developments
The EC has proposed that the minimum mesh size for *Nephrops* in the rest of Region 2 should be increased to 80mm and that square mesh windows should be fitted. There could be a wish to have consistency between fishing areas and the same changes made in the Skagerrak and Kattegat. Swedish vessels have been fishing under special licence with codends made completely from 60mm square mesh netting. There may be a desire to formally permit or even stipulate use of these codends in this fishery but at present there seems to be few proven advantages of using them.

5.3.2 Nephrops model

In some recent analyses the complementary log-log selection curve has given the best fit to *Nephrops* catch data. As most data sets have been fitted with the logistic selectivity curve, however, it is recommended that this should again be used. The model for retention probability ***r*** of a *Nephrops* of carapace length ***l*** mm **in a codend** is then:-

$$r(l) = \exp(a + bl) / (1 + \exp(a + bl))$$

where b = **SRange** mm / **2.197 = SRatio * mesh size** mm / **2.197**
and a = **-L50** mm * b = **-SF * mesh size** mm *b

For the different types of codend that are used in the fishery or could be stipulated in the future, the appropriate estimated values of SF and SRatio are:-

Codend type	Reference mesh size	SF	SRatio
Standard or window	Codend	0.41	0.20
Square mesh	Codend	0.53	0.21

The above formula can be used to model the effect of changes in minimum mesh size between 70 and 80mm. If scenarios of increases in mesh size above 80mm are to be evaluated then there is the problem that many fishermen will have to increase mesh in the main body of the trawl as they currently use 80mm. As *Nephrops* also escape through the main body of the trawl the numbers entering the codend will change. In the experiments conducted by Lehmann 1993, previously referred to in section 4.1.6, he was able to describe the selectivity of a 110mm trawl body relative to a 80mm trawl body by a logistic curve with L50 of 37mm carapace length and SRange 20mm. The order of magnitude of the effect of having to change mesh size in the trawl body as well as the codend could be estimated by first applying Lehmann's logistic curve to give the change in numbers at length entering the codend, then multiplying by the ratio of the retention rates for the new and old codend mesh sizes.

5.3.3 Fish bycatch models

The models produced in 5.4.3 for sole and plaice could be applied.

5.4 Kattegat whitefish trawlers and anchor seiners

5.4.1 Current gears and future possible developments

Legislation
The current minimum mesh size is 90mm and there are no special restrictions on other codend parameters.

Current gear specifications
It is understood that some trawlers tow a single trawl and some use a twin trawl system. Some trawlers use a mesh size just above 90mm but others, particularly those that also fish in the adjacent areas subject to the Baltic minimum mesh size of 105mm, will use mesh sizes above 105mm. It is thought the anchor seiners targeting plaice will probably use codend mesh sizes above 105mm. It was reported by one of the principal net makers that 4mm double braided PET is the standard codend material and most codends are 100 meshes round including the selvedges (giving 84 to 96 open meshes).

Possible future developments
The EC has proposed that minimum mesh sizes in all areas of Region 2 except the Skagerrak and Kattegat should be increased to 110mm for cod and decreased to 80mm for plaice. There may well be a desire to have the same minimum mesh sizes also introduced to the Kattegat and Skagerrak. A desire for standardisation of legislation could also lead to limiting the number of open meshes round the codend circumference to 100 (already introduced in the North Sea) and compulsory use of square mesh panels of a mesh size equal to or greater than that of the codend (a further EC proposal for Region 2 except the Skagerrak and Kattegat).

5.4.2 Cod model

No model can be suggested as no measurements of selectivity have been obtained in this area and Kattegat cod are understood to be morphologically different to Baltic and North sea cod. If a study of length- girth relationships in the three areas showed that these could explain the 11% difference between Baltic and North Sea cod SF estimates, then it may be possible to make a "guesstimate" of the selectivity parameters for Kattegat cod from a knowledge of its mean girth-length relationship.

5.4.3 Sole and plaice models

The Logistic curve model for retention probability r of a fish of length l cm is again used:-

$$r(l) = \exp(a + bl) / (1 + \exp(a + bl))$$

where b = **SRange** cm / **2.197 = SRatio * mesh size** mm / **21.97**
and a = **-L50** cm * b = **-SF * mesh size** mm *b / **10**

The selectivity parameter estimates principally deriving from North Sea beam trawlers are all that are available and therefore have to be used. The appropriate estimated values of SF and SRatio for the two species are:-

Species	SF	SRatio
Sole	3.11	0.48
Plaice	2.19	0.33

5.5 Kattegat gillnetters

5.5.1 Current gears and future possible developments

Legislation
There are currently no restrictions on gear parameters such as mesh size.

Current gear specifications
It was reported by netmakers that mesh sizes of 120-140mm are used for targeting cod and plaice. Trammels are most popular but conventional gill nets are also used. Mesh sizes for targeting sole

with conventional gill nets are in the range 92-108mm in line with the practice in other Danish fishing areas. Trammels with mesh sizes above 120mm can also be used for targeting sole.

Possible future developments
The EC has proposed that minimum mesh sizes of 100mm for sole and plaice and 120mm for cod be introduced throughout Region 2 including the Kattegat in 1998.

5.5.2 Cod model

No measurements of gill net selectivity for Kattegat cod were available, as was the case with towed gears, so again no model can be given. It may be possible to produce "guesstimates" of the selectivity parameters from those for North Sea cod by adjusting them in accordance with differences in girth-length relationships (***k*** and ***st*** should be inversely proportional to the girth to length ratio).

5.5.3 Sole and plaice models

The relative retention rate or selectivity S for a fish of transformed length ***tl*** (= length in cm*10 / full inside mesh size in mm) is given by

for $tl < k$ $\quad S(tl) = (1-C1) * \exp(-\frac{1}{2}*((tl-k)/st)^2) + C1$

for $tl >= k$ $\quad S(tl) = (1-C2) * \exp(-\frac{1}{2}*((tl-k)/st)^2) + C2$

where
k is the modal value = modal length to mesh size ratio
st is the spread or standard deviation of the normal distribution describing enmeshing (prior to scaling)
C1 is the probability of fish under modal length being caught by random entangling
C2 is the probability of fish above modal length being caught by random entangling.

No gill net selectivity data have been obtained in the Kattegat but from the available data sets there do not appear to be large differences between the estimates of the first three parameters obtained with different designs of gill net or different fishing areas. *C2* was, however, found to be higher for sole in trammels than gillnets. Appropriate mean values for the selectivity parameters are given in the following table:-

Parameter	Sole	Plaice
k	3.249	2.533
st	0.255	0.324
C1	0.035	0.000
C2 gillnets	0.219	0.150
C2 trammels	0.508	0.150

6. Survival rates of discards and codend escapees

6.1 Cod codend escapees

Measurements of the survival rates of Baltic cod escaping through window codends have been made in a joint Swedish-Finnish experiment, Suuronen et al 1995. Survival was extremely high only 2 out of 261 cod dying but they were in the size range 24-50cm. Survival rates of large roundfish have always been found to be high in such experiments. This has not, however, always been the case for small juvenile roundfish. Detailed studies of haddock and whiting survival, Lowry et al 1996, appeared to show that survival was highly size and age dependant. Within each age class smaller fish were more likely to die than large ones. Overall fish under 1 year old had very low survival rate, 1 year olds a moderate survival rate and older fish a high survival rate. Similar experiments have, however, recently been carried out (August 1997) by the same institutes in which the time over which the samples of fish escaping from the codend were collected in the codend cover was made very short (10-15 minutes) by using a remote system for opening and closing the codend covers. The survival rates of all sizes and ages of haddock and whiting were then found to be very high.

Further survival measurements for Baltic cod will shortly be obtained in an EC FAIR project BACOMA in which several institutes including DIFTA are participating.

6.2 Cod discards

An experiment carried out in the USA is briefly described in Anon 1995 in which the survival of undersized cod trawl discards was found to be between 0 and 25% dependant upon tow length and deck treatment.

6.3 Sole and plaice codend escapees

A review of the survival of fish escaping from fishing gears is to be found in Anon 1994. Dutch experiments in the North Sea suggest that survival rates for these species in beam trawl fisheries are relatively high 60-100%.

6.4 Sole and plaice discards

The review presented in Anon 1994 revealed conflicting results for different experiments. Dutch experiments estimated that in commercial beam trawling survival of deck discards of immatures of these species was as low as 10%. English experiments with small trawls indicated that short term survival of undersized plaice was over 80% and long term survival over 50%.

6.5 Nephrops discards

Experiments have recently been conducted off the west coast of Scotland, Anon 1997b. *Nephrops* under 40mm carapace length caught in 70mm codends were studied. Deck discards were transferred to pens with individual artificial burrows. Survival rates in the 3 pens were 23.4%, 34.3% and 37.5%. This work is to be repeated in summer 1997. Older experiments conducted in the Bay of Biscay and Celtic Sea gave survival rates of 31% and 19% respectively, Chareau et al 1982.

6.6 Nephrops codend escapees

Survival of *Nephrops* escaping through codend meshes has also been studied in the recent Scottish west coast experiments, Anon 1997b. Mean survival rate for 60mm square mesh codends was 86% (range 72-95%) and for 100mm diamond mesh codends 79% (range 73-87%). Survival did not appear to be dependant on *Nephrops* length. Further experiments will be made in summer 1997 including measurements for 70mm diamond mesh codends.

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Appendix 1

Notation and references for the towed gear selectivity database

Notes on Codend Selectivity Database

Fish species

B.COD = Baltic cod, the standard FAO 3 letter codes are used otherwise.

Vessel nationality - type

A two part code is used the first three letters of the country followed by a hyphen and then either C for a commercial vessel or R for a research vessel.

Gear Type

The standard ISSCFG 3 letter codes are used

OTB	Single boat (otter) bottom trawl
PTB	2 boat (pair) bottom trawl
SDN	Danish (anchor) seine
SPR	2 boat (pair) seine
SSC	Scottish (fly-dragging) seine
TBB	Beam trawl
TBN	Nephrops trawl

Experimental method

The following codes are used:-

C+Fl	Covered codend with the cover having floats attached.
C+2.3mH	Covered codend with the cover fitted with 2 hoops the largest situated at the catch in the test codend being 2.3m in diameter and outside the cover.
C+3mIH	Covered codend with the cover fitted with 2 hoops the largest situated at the catch in the test codend being 3m in diameter and fixed inside the cover.
C+SH	Covered codend with the cover fitted with a single hoop situated at the start of the codend and the main part of the cover having floats attached.
DIV	Divided trawl composed of two equal halves which are totally separate aft of the footrope. Two bellies of equal overall dimensions are joined together at the centre of a single footrope. Each belly connects to one of the two trawl wings, one has the test codend attached and the other a small mesh codend.
TR	Trouser trawl where the trawl is fitted aft with a vertical dividing panel and the aft belly divides into 2 codends with one in small mesh towed alongside each other.
TW	Twin trawl system of two identical trawls with the test codend attached to one and the small mesh codend to the other.
TW-CF	Twin trawl system of two identical trawls but with different codend mesh sizes (comparative fishing). Indirect estimate of selectivity parameters obtained without an estimate of the fish population.
TW-FTS	Twin trawl system with two trawls of equal overall dimensions but one totally in small meshes in order to estimate full trawl selectivity of the test trawl.

Codend

The mesh opening is the legal mesh size as measured with the EEC wedge gauge with 5kg hanging weight. Measurements taken with the ICES gauge at 4 kg tension have been increased by 4% for normal twines.

The circumference in open meshes excludes those closed in the selvedges.

The codend total length includes all parallel sided codend extensions.

Twine is the manufacturers nominal (single twine) diameter. Db indicates double twine and S single twine.

Selectivity curve model

A 4 part code is used with each part separated by hyphens.

Part 1 is a single letter giving the model for the selectivity curve for an individual haul.

- C Complimentary log-log
- L Logistic
- N Non-Parametric
- O Any other "unconventional" parametric curve
- P Probit

The specification of the parametric curves is given in ref. A.

Part 2 is a single letter specifying whether catches have been sampled and if so whether the selectivity curve has been fitted to the scaled total catch numbers or the actual numbers of measured fish and the sampling ratios.

- A No sampling, length of all fish caught measured.
- M Catches sampled with selectivity curve fitted to the measured fish and their sampling ratios.
- O Occasional sampling with all fish being measured on the majority of hauls, the selectivity curve fitted to the estimated scaled up total catch numbers for hauls with sampling.
- S Catches sampled with the selectivity curve fitted to the estimated scaled up total catch numbers.

Part 3 is a single letter specifying whether or not the catch data has been pooled over hauls prior to curve fitting.

- H Selectivity curve fitted to each individual haul.
- P Catch data pooled over hauls.

Part 4 is a character string specifying the overall model of selectivity (including variability between hauls) and curve fitting technique.

F	Freyer's model of between haul variation in selectivity: reference B.
FF	Freyer's Fixed and Random effects model where the selectivity parameters are linearly related to explanatory variables which can vary between haul or codend design: reference B.
HB	Holst's use of bootstrapping techniques to account for between haul variation in selectivity: reference C.
IE	Indirect estimate of selectivity parameters when no small mesh codend has been used to estimate the population.
IR	Isotonic regression technique of curve fitting.
M	Mean of haul by haul selectivity parameters (L50, SR).
S	Millar's SELECT model for "paired gears" allowing for differences in the probability that fish encounter the test or small mesh codend: reference D.
S50	Millar's SELECT model with forced 0.5 probability that fish encounter the test codend.

Appendix 2

Towed gear selectivity database

Baltic cod
Cod North Sea / Skagerrak
Plaice
Nephrops

Species	B.COD	Codend type	Standard	Sheet number	1

Reference	1	1	3	3	3	3	3	3	3	4
ICES Area	IIId	IIId	IIId	IIId	IIId	IIId	IIId	IIId	IIId	IIId
Test date	Jul-94	Aug-94	Jul-94	Dec-94	Dec-94	Mar-95	Mar-95	Jun-95	Jun-95	Aug-95
Vessel nationality - type	DEN-C	DEN-C	SWE-C	SWE-C	SWE-C	SWE-C	SWE-C	SWE-C	SWE-C	GER-C
Vessel HP	290	290	1180	898	1180	898	898	1180	898	300
Gear type	OTB	OTB	OTB	OTB	OTB	OTB	OTB	OTB	OTB	OTB
Experimental method	C+2.3mH	C+2.3mH	C+1.8mH	C+1.8mH	C+1.8mH	C+1.8mH	C+1.8mH	C+1.8mH	C+1.8mH	C+H
Codend										
Mesh opening mm	107.4	122.8	107.0	123.0	123.0	123.0	140.0	123.0	123.0	109.0
Circumf. open meshes	96	96	100	88	88	88	72	88	88	
Total length	11.5	11.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	
Twine	4mmDb	4mmDb	4mmDb	4mmDb	4mmDb	4mmDb	4mmDb	4mmDb	4mmDb	4mmS
Window type										
Mesh opening mm										
Fishing conditions										
Codend catch / haul kg	6017	2093	494	1011	902	763	965	622	1483	265
Cover catch / haul kg	391	583								
Towing time hours	2.3	2.9								
Wind speed m/sec	4.0	5.0	2.7	6.3	7.6	9.0	7.8	4.3	4.0	1.0
Sea state										
Selectivity curve model	P-S-H-F	P-S-H-F	N-H-HB	N-H-HB	N-H-HB	N-H-HB	N-H-HB	N-H-HB	N-H-HB	L-H-F
Valid hauls	3	6	7	11	11	11	12	18	6	4
Number in Sel. Range										
L25 cm	27.9	32.5	24.1				39.1			33.1
L50 cm	31.8	37.5	26.9	35.1	37.2	30.5	45.0	36.1	35.3	36.4
Selection factor	2.96	3.05	2.51	2.86	3.03	2.48	3.22	2.93	2.87	3.34
Selection range cm	7.7	9.9	6.8	8.5	12.1	8.3	11.7	9.9	7.3	6.6

Species	B.COD		Codend type	Standard			Sheet number	1

Other data										
Vessel name	Ulvedal	Ulvedal	Emilia	Kungso	Emilia	Kungso	Kungso	Emilia	Kungso	Weisswal
L50 standard error										
L50 lower 95% con.lim.	31.3	36.4	25.5	34.2	35.5	28.7	43.1	34.9	34.4	
L50 upper 95% con.lim.	32.3	39.6	28.4	35.7	40.5	31.5	46.0	36.7	36.1	
SR standard error										
SR lower 95% con.lim.	7.3	9.3	5.2	7.5	9.9	7.1	10.1	7.6	6.0	
SR upper 95% con.lim.	8.1	10.5	7.9	9.8	17.4	10.4	14.7	11.7	8.6	
Selection ratio	0.72	0.81	0.63	0.69	0.99	0.68	0.84	0.80	0.59	0.61
Parameter a	-5.57	-5.11								-12.12
Parameter b	0.175	0.136								0.333
Parameter p										
Variance r11										
Variance r22										
Variance r33										
Covariance r12										
Covariance r13										
Covariance r23										
Between haul variance										
Variance d11										
Variance d22										
Variance d33										
Covariance d12										
Covariance d13										
Covariance d23										

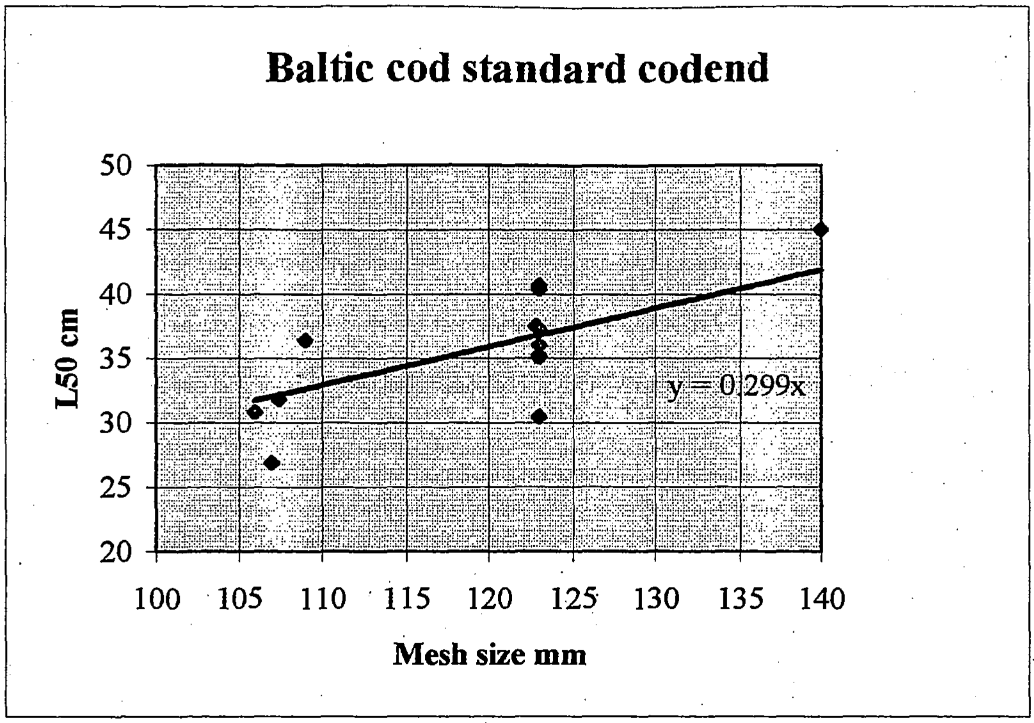
Species	B.COD		Codend type	Standard		Sheet number	2

Reference	21	21	21							
ICES Area	IIId	IIId	IIId							
Test date	Jun-96	Jun-96	Jun-96							
Vessel nationality - type	GER-R	GER-R	GER-C							
Vessel HP	800	800	300							
Gear type	OTB	OTB	OTB							
Experimental method	C+H	C+H	C+H							
Codend										
Mesh opening mm	123.0	106.0	123.0							
Circumf. open meshes										
Total length										
Twine										
Window type										
Mesh opening mm										
Fishing conditions										
Codend catch / haul kg	335	465	305							
Cover catch / haul kg										
Towing time hours	2.0	2.0	2.4							
Wind speed m/sec	fce3	fce1	fce4							
Sea state										
Selectivity curve model	L-A-H-F	L-A-H-F	L-A-H-F							
Valid hauls	6	6	12							
Number in Sel. Range										
L25 cm	37.5	26.3	36.3							
L50 cm	40.7	30.8	40.4							
Selection factor	3.31	2.90	3.28							
Selection range cm	6.5	9.0	8.3							

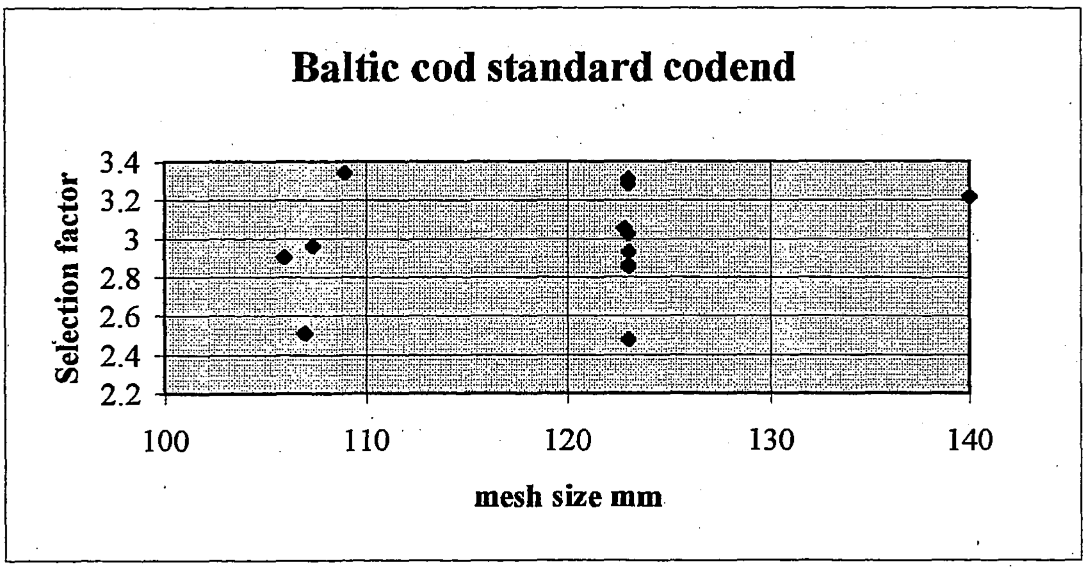
Species	B.COD	Codend type	Standard	Sheet number	2

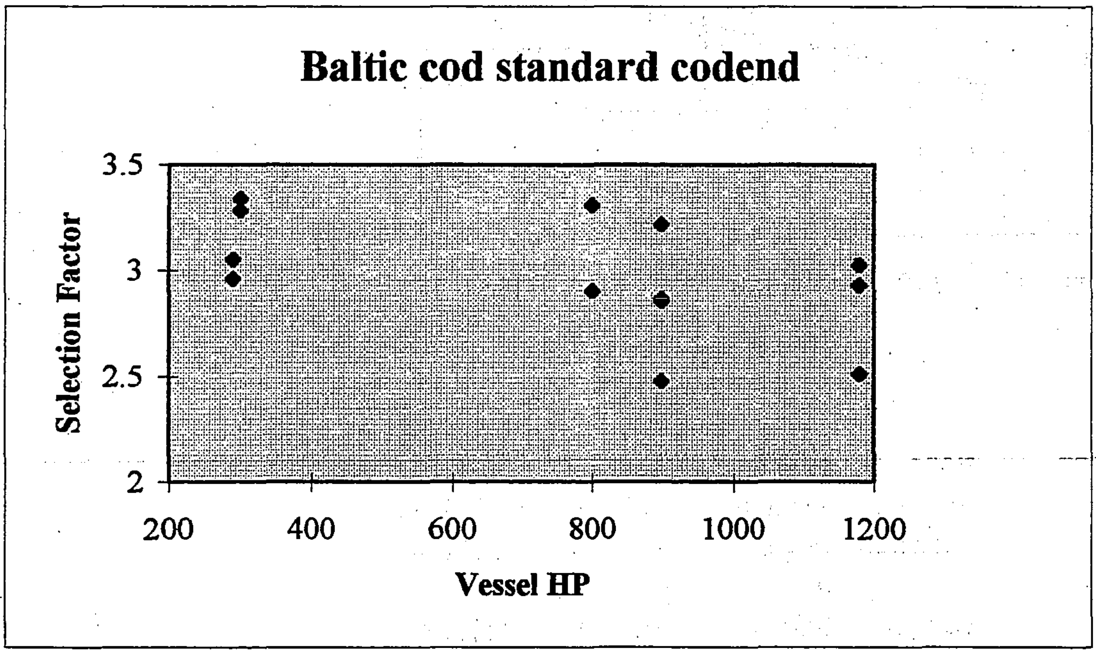
Other data										
Vessel name	Solea	Solea	Delphin							
L50 standard error										
L50 lower 95% con.lim.	40.1	20.4	39.6							
L50 upper 95% con.lim.	41.2	31.4	41.0							
SR standard error										
SR lower 95% con.lim.	5.9	7.8	6.9							
SR upper 95% con.lim.	7.1	10.2	9.6							
Selection ratio	0.53	0.85	0.67							
Parameter a	-13.81	-7.49	-10.75							
Parameter b	0.339	0.243	0.266							
Parameter p										
Variance r11	0.4360	0.6277	0.8989							
Variance r22	0.0002	0.0003	0.0005							
Variance r33										
Covariance r12	-0.1021	-0.01289	-0.02068							
Covariance r13										
Covariance r23										
Between haul variance										
Variance d11	0.9088	3.3169	9.4699							
Variance d22	0.0004	0.0012	0.0049							
Variance d33										
Covariance d12	-0.01845	-0.06393	-0.21527							
Covariance d13										
Covariance d23										

Data Summary	B.COD	Codend type		Standard
Number of data sets	13			
Number of hauls	113			
Number of vessels	6			
		95%Confidence limits		Maximum	Minimum
Mean Selection factor	2.98	3.13	2.83	3.34	2.48
weighted by hauls	2.97				
weighted by sqrt(hauls)	2.97				
Mean Selection range cm	8.7	9.7	7.7	12.1	6.5
weighted by hauls	9.1				
weighted by sqrt(hauls)	8.9				
Mean Selection ratio	0.72	0.79	0.65	0.99	0.53
weighted by hauls	0.74				
weighted by sqrt(hauls)	0.73				

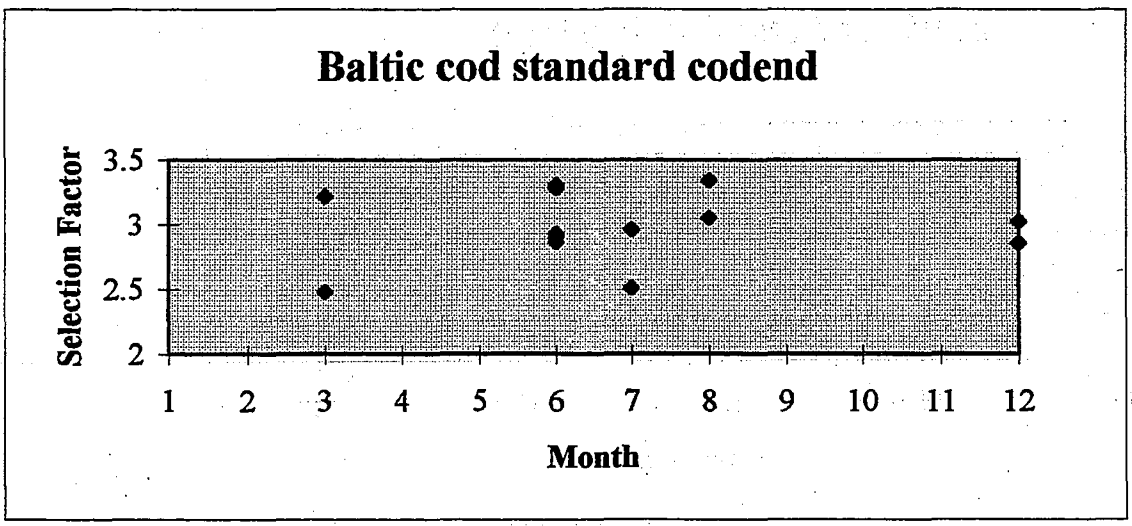


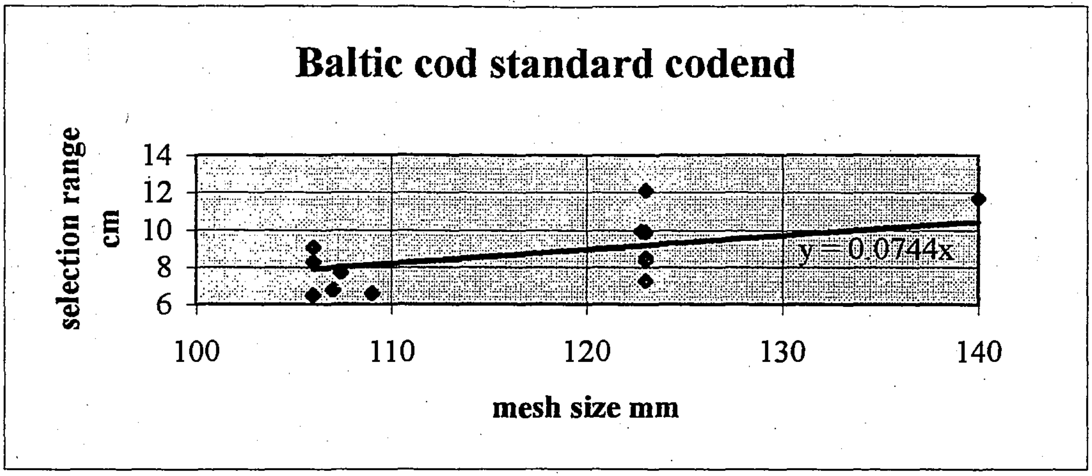
Linear regression	slope	intercept	0.388963	-10.8083
L50-mesh size	se slope	se interc	0.097884	11.72983
	r squared	se yest	0.589407	3.264158
	F	df	15.79054	11
	SS regr	SS resid	168.2439	117.202
Forced through origin	slope	intercept	0.299039	0
	se slope	se interc	0.007507	#N/A
	r squared	se yest	0.557715	3.243563
	F	df	15.13184	12
	SS regr	SS resid	159.1975	126.2484



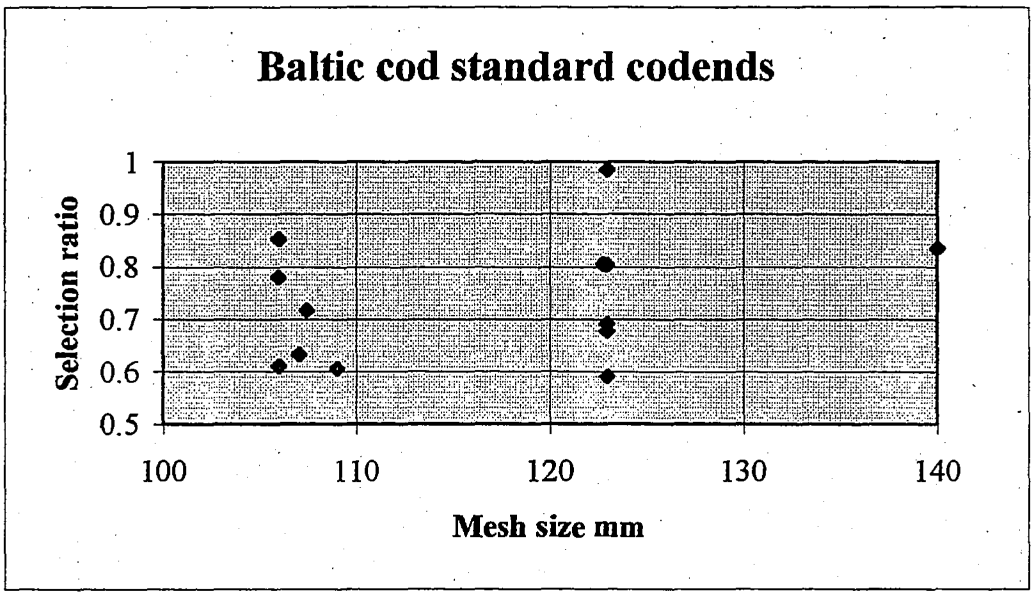


Linear regression	slope	intercept	-0.0004	3.284258
SF-Vessel HP	se slope	se interc	0.000203	0.169121
	r squared	se yest	0.260378	0.246306
	F	df	3.872456	11
	SS regr	SS resid	0.234928	0.667332





Linear regression	slope	intercept	0.119528	-5.30962
SR-mesh size	se slope	se interc	0.03711	4.353351
	r squared	se yest	0.48536	1.369336
	F	df	10.37417	11
	SS regr	SS resid	19.45241	20.6259
Forced through origin	slope	intercept	0.074439	0
	se slope	se interc	0.003303	#N/A
	r squared	se yest	0.415763	1.396878
	F	df	8.53962	12
	SS regr	SS resid	16.66309	23.41522



Species	B.COD		Codend type	Window			Sheet number	2

Reference	3	3	3	3	3	3				
ICES Area	IIId	IIId	IIId	IIId	IIId	IIId				
Test date	Jul-94	Dec-94	Jun-95	Jun-95	Jun-95	Jun-95				
Vessel nationality - type	SWE-C	SWE-C	SWE-C	SWE-C	SWE-C	SWE-C				
Vessel HP	1180	898	1180	1180	898	898				
Gear type	OTB	OTB	OTB	OTB	OTB	OTB				
Experimental method	C+1.8mH	C+1.8mH	C+1.8mH	C+1.8mH	C+1.8mH	C+1.8mH				
Codend										
Mesh opening mm	107.0	107.0	107.0	107.0	107.0	107.0				
Circumf. open meshes	100	100	100	100	100	100				
Total length	19.5	19.5	19.5	19.5	19.5	19.5				
Twine	4mmDb	4mmDb	4mmDb	4mmDb	4mmDb	4mmDb				
Window type	**Swedish**	**Swedish**	**Swedish**	**Swedish**	**Swedish**	**Swedish**				
Mesh opening mm	97.0	103.0	103.0	117.0	103.0	117.0				
Fishing conditions										
Codend catch / haul kg	541	1077	937	1267	412	431				
Cover catch / haul kg										
Towing time hours										
Wind speed m/sec	3.8	8.2	2.9	4.6	5.4	5.8				
Sea state										
Selectivity curve model	N-H-HB	N-H-HB	N-H-HB	N-H-HB	N-H-HB	N-H-HB				
Valid hauls	10	11	13	8	12	10				
Number in Sel. Range										
L25 cm				35.9						
L50 cm	34.3	34.4	37.2	39.8	36.7	43.3				
Selection factor window	3.53	3.34	3.61	3.40	3.56	3.70				
Selection range cm	7.2	8.2	5.4	7.9	5.8	5.8				

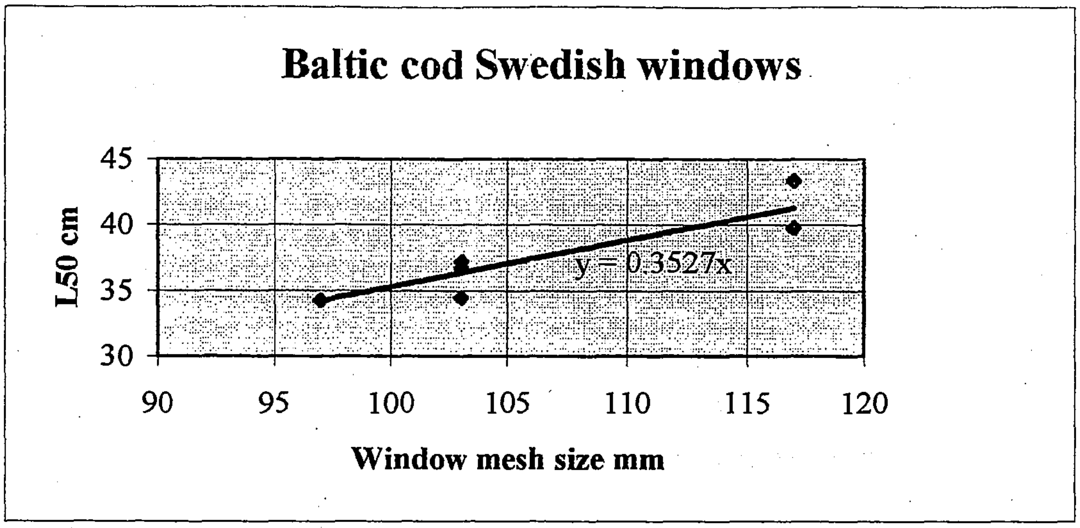
Species	B.COD

Codend type	Window

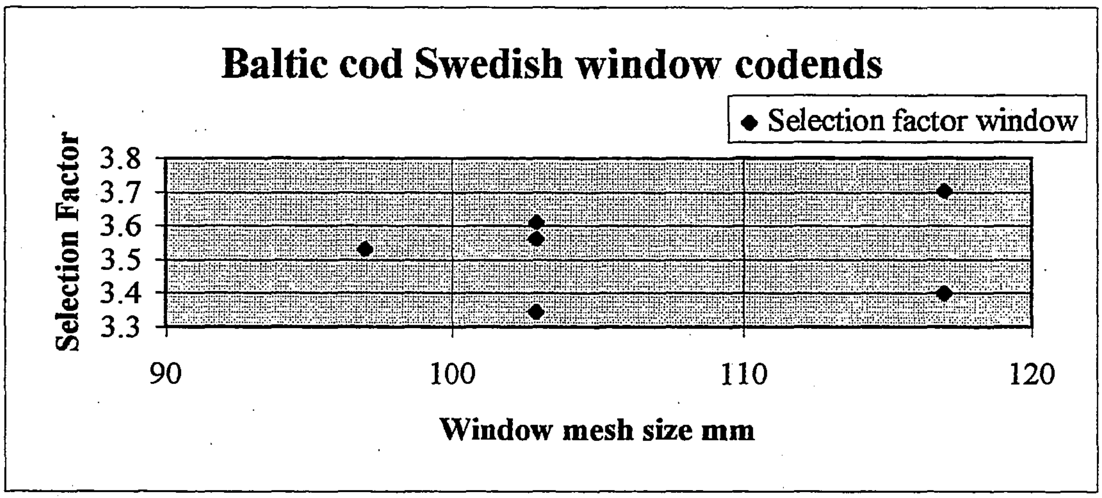
Sheet number	2

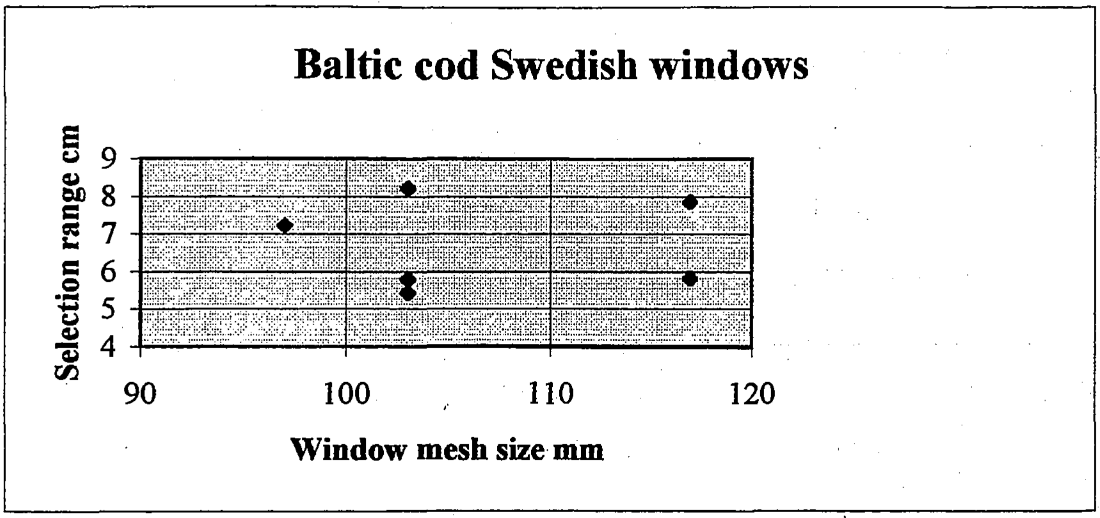
Other data										
Vessel name	Emilia	Kungso	Emilia	Emilia	Kungso	Kungso				
L50 standard error										
L50 lower 95% con.lim.	33.7	33.8	36.5	37.9	35.8	42.2				
L50 upper 95% con.lim.	34.8	35.3	37.9	42.6	37.4	44.4				
SR standard error										
SR lower 95% con.lim.	6.1	7.5	5.1	7.1	5.0	5.0				
SR upper 95% con.lim.	8.1	9.8	7.1	9.0	6.7	7.8				
Selection ratio window	0.74	0.80	0.53	0.67	0.56	0.50				
Parameter a										
Parameter b										
Parameter p										
Variance r11										
Variance r22										
Variance r33										
Covariance r12										
Covariance r13										
Covariance r23										
Between haul variance										
Variance d11										
Variance d22										
Variance d33										
Covariance d12										
Covariance d13										
Covariance d23										

Data Summary	**B.COD**	**Codend type**		**Swedish Window**	
Number of data sets	6				
Number of hauls	64				
Number of vessels	2				
		95%Confidence limits		Maximum	Minimum
Mean Window Selection factor	3.52	3.63	3.42	3.70	3.34
weighted by hauls	3.53				
weighted by sqrt(hauls)	3.53				
Mean Selection range cm	6.7	7.7	5.8	8.2	5.4
weighted by hauls	6.6				
weighted by sqrt(hauls)	6.7				
Mean Window selection ratio	0.63	0.73	0.54	0.80	0.50
weighted by hauls	0.63				
weighted by sqrt(hauls)	0.63				



Linear regression	slope	intercept	0.375365	-2.43057
L50-mesh size	se slope	se interc	0.087802	9.389364
	r squared	se yest	0.82044	1.636359
	F	df	18.27662	4
	SS regr	SS resid	48.9388	10.71069
Forced through origin	slope	intercept	0.352693	0
	se slope	se interc	0.005634	#N/A
	r squared	se yest	0.817431	1.475813
	F	df	22.38697	5
	SS regr	SS resid	48.75936	10.89012





Linear regression	slope	intercept	0.000422	6.678292
SR-mesh size	se slope	se interc	0.071437	7.639287
	r squared	se yest	8.73E-06	1.331359
	F	df	3.49E-05	4
	SS regr	SS resid	6.19E-05	7.090071

Species	B.COD		Codend type	Window			Sheet number	1

Reference	1	1	1	2	4					
ICES Area	IIId	IIId	IIId	IIId	IIId					
Test date	Jul-94	Aug-94	Aug-94	Aug-95	Aug-95					
Vessel nationality - type	DEN-C	DEN-C	DEN-C	DEN-C	GER-C					
Vessel HP	290	290	290	290	300					
Gear type	OTB	OTB	OTB	OTB	OTB					
Experimental method	C+2.3mH	C+2.3mH	C+2.3mH	C+2.5mH	C+H					
Codend										
Mesh opening mm	107.4	107.4	107.4	106.7	109.0					
Circumf. open meshes	92	92	92	92						
Total length	11.5	11.5	11.5	6.0						
Twine	4mmDb	4mmDb	4mmDb	4mmDb	4mmS					
Window type	**Danish**	**Danish**	**Danish**	**Danish**	**Danish**					
Mesh opening mm	107.0	115.7	121.1	115.0	119.0					
Fishing conditions										
Codend catch / haul kg	2842	2522	1919	448	375					
Cover catch / haul kg	299	831	917	140						
Towing time hours	2.3	3.4	3.5	3.7						
Wind speed m/sec	3.0	3.0	4.0	5.7	10.0					
Sea state				3						
Selectivity curve model	P-S-H-F	P-S-H-F	P-S-H-F	L-A-H-F	L-A					
Valid hauls	4	6	6	25	1					
Number in Sel. Range										
L25 cm	28.7	31.9	34.0	29.5	33.9					
L50 cm	32.7	36.1	38.3	32.6	38.4					
Selection factor window	3.06	3.12	3.16	2.83	3.23					
Selection range cm	8.0	8.3	8.5	6.2	9.0					

Species	**B.COD**	**Codend type**	**Window**	**Sheet number**	**1**

Other data										
Vessel name	Ulvedal	Ulvedal	Ulvedal	Ulvedal	Weisswal					
L50 standard error										
L50 lower 95% con.lim.	32.3	34.2	37.2	31.9						
L50 upper 95% con.lim.	33.0	38.1	39.2	33.2						
SR standard error										
SR lower 95% con.lim.	7.0	7.9	7.6	5.7						
SR upper 95% con.lim.	9.1	8.7	9.3	6.6						
Selection ratio window	0.75	0.72	0.70	0.54	0.76					
Parameter a	-5.51	-5.87	-6.08	-11.61	-12.12					
Parameter b	0.169	0.163	0.159	0.356	0.333					
Parameter p										
Variance r11										
Variance r22										
Variance r33										
Covariance r12										
Covariance r13										
Covariance r23										
Between haul variance										
Variance d11										
Variance d22										
Variance d33										
Covariance d12										
Covariance d13										
Covariance d23										

Species	B.COD	Codend type	Window	Sheet number	3

Reference	3	4	21	21	21	21	21	21		
ICES Area	IIId	IIId	IIId	IIId	IIId	IIId	IIId	IIId		
Test date	Dec-94	Aug-95	Jun-96	Jun-96	Jun-96	Jun-96	Jun-96	Jun-96		
Vessel nationality - type	SWE-C	GER-C	GER-R	GER-R	GER-R	GER-C	GER-C	GER-C		
Vessel HP	898	300	800	800	800	300	300	300		
Gear type	OTB	OTB	OTB	OTB	OTB	OTB	OTB	OTB		
Experimental method	C+1.8mH	C+H	C+H	C+H	C+H	C+H	C+H	C+H		
Codend										
Mesh opening mm	107.0	109.0	106.0	106.0	106.0	106.0	106.0	106.0		
Circumf. open meshes	100									
Total length	19.5									
Twine	4mmDb	4mmS								
Window type	**German**	**German**	**German**	**German**	**German**	**German**	**German**	**German**		
Mesh opening mm	105.0	114.0	108.0	112.0	121.0	112.0	121.0	108.0		
Fishing conditions										
Codend catch / haul kg	557	153	426	456	466	377	552	1018		
Cover catch / haul kg										
Towing time hours			1.9	2.1	2.2	2.4	2.7	3.0		
Wind speed m/sec	7.3	4.0	fce4	fce5	fce3-4	fce5	fce3	fce1-2		
Sea state										
Selectivity curve model	N-O-H-HB	L-A-H-F	L-A-H-F	L-A-H-F	L-A-H-F	L-A-H-F	L-A-H-F	L-A-H-F		
Valid hauls	3	6	4	6	6	5	5	2		
Number in Sel. Range										
L25 cm	30.2	34.4	30.4	29.8	28.3	31.3	31.5	31.8		
L50 cm	34.2	37.5	33.8	33.5	32.8	35.0	36.4	35.1		
Selection factor window	3.26	3.29	3.13	2.99	2.71	3.13	3.01	3.25		
Selection range cm	8.1	6.2	6.9	7.3	8.9	7.8	9.8	6.7		

Species	B.COD	Codend type	Window	Sheet number	3

Other data										
Vessel name	Kungso	Weisswal	Solea	Solea	Solea	Delphin	Delphin	Delphin		
L50 standard error										
L50 lower 95% con.lim.	32.9		32.4	31.9	30.6	34.7	34.6	34.3		
L50 upper 95% con.lim.	36.1		35.0	34.8	34.9	35.4	38.0	37.1		
SR standard error										
SR lower 95% con.lim.	6.5		5.7	6.5	7.9	6.9	8.8	3.8		
SR upper 95% con.lim.	11.7		8.2	8.1	10.0	8.7	10.9	9.7		
Selection ratio window	0.77	0.54	0.64	0.65	0.74	0.70	0.81	0.62		
Parameter a		-13.29	-10.73	-10.05	-8.06	-9.87	-8.12	-11.44		
Parameter b		0.354	0.317	0.300	0.246	0.282	0.223	0.326		
Parameter p										
Variance r11			1.3212	0.5715	0.3751	0.3144	0.3256	5.5218		
Variance r22			0.0009	0.0003	0.0002	0.0003	0.0001	0.0051		
Variance r33										
Covariance r12			-0.03334	-0.01253	-0.00837	-0.00881	-0.00651	-0.16811		
Covariance r13										
Covariance r23										
Between haul variance										
Variance d11			4.3873	2.6418	1.8093	0.8549	1.3128	10.3351		
Variance d22			0.0027	0.0011	0.0010	0.0007	0.0005	0.0097		
Variance d33										
Covariance d12			-0.10753	-0.05295	-0.03728	-0.02397	-0.02405	-0.31709		
Covariance d13										
Covariance d23										

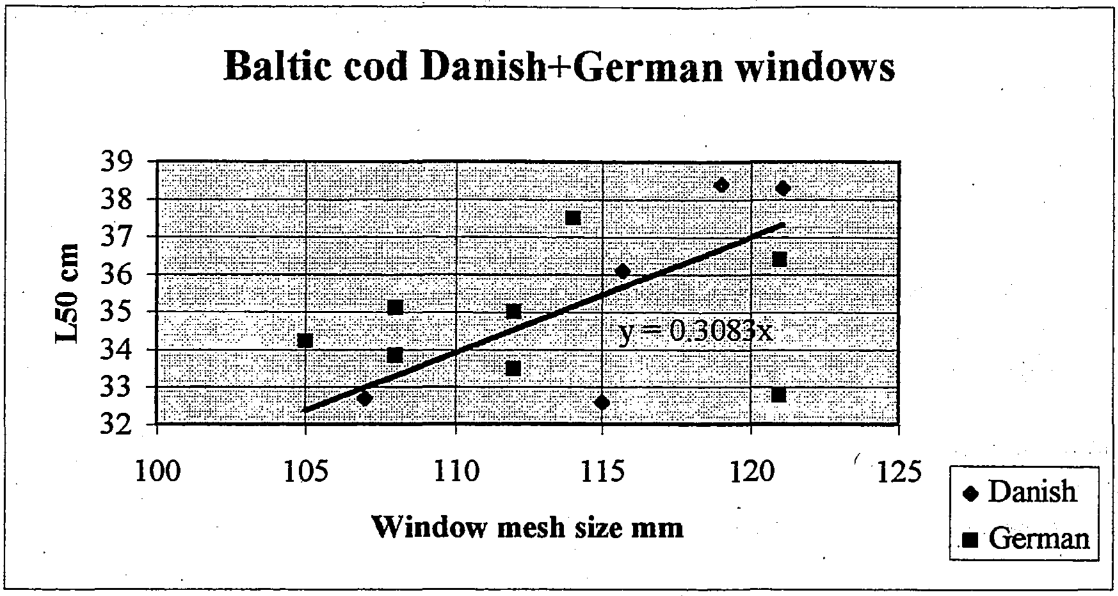
Data Summary	B.COD	Codend type		Danish Window	
Number of data sets	5				
Number of hauls	42				
Number of vessels	2				
		95%Confidence limits		Maximum	Minimum
Mean Window Selection factor	3.08	3.21	2.95	3.23	2.83
weighted by hauls	2.95				
weighted by sqrt(hauls)	3.02				
Mean Selection range cm	8.0	8.9	7.0	9.0	6.2
weighted by hauls	7.0				
weighted by sqrt(hauls)	7.5				
Mean Window selection ratio	0.69	0.77	0.61	0.76	0.54
weighted by hauls	0.61				
weighted by sqrt(hauls)	0.65				

Data Summary	**COD**	**Codend type**		**German Window**	
Number of data sets	8				
Number of hauls	37				
Number of vessels	4				
		95%Confidence limits		Maximum	Minimum
Mean Window Selection factor	3.10	3.23	2.96	3.29	2.71
weighted by hauls	3.07				
weighted by sqrt(hauls)	3.08				
Mean Selection range cm	7.7	8.6	6.9	9.8	6.2
weighted by hauls	7.8				
weighted by sqrt(hauls)	7.8				
Mean Window selection ratio	0.68	0.74	0.62	0.81	0.54
weighted by hauls	0.68				
weighted by sqrt(hauls)	0.68				
Mean Selection factor*	3.27	3.35	3.18	3.44	3.09
weighted by hauls	3.27				
weighted by sqrt(hauls)	3.27				
Mean selection ratio*	0.73	0.81	0.65	0.92	0.57
weighted by hauls	0.73				
weighted by sqrt(hauls)	0.73				

* Based on codend mesh size

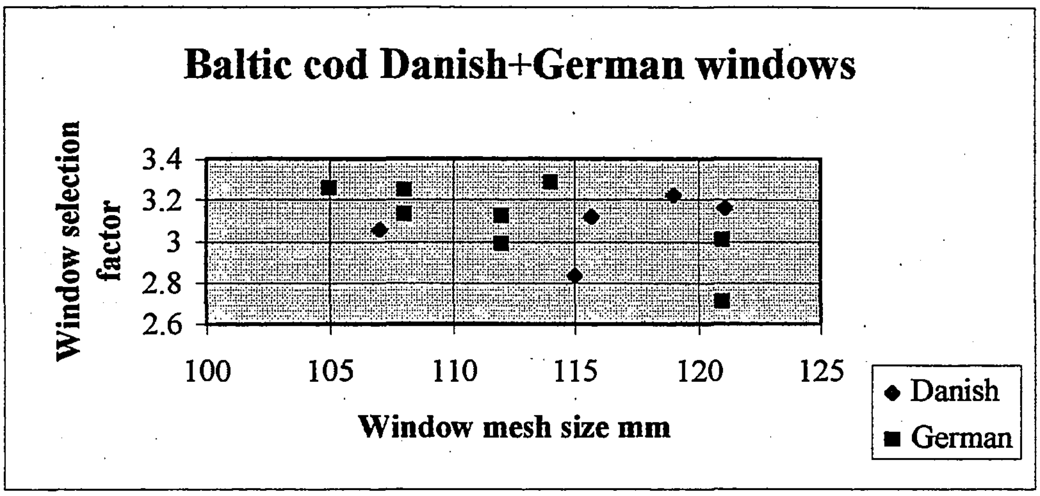
Data Summary	**B.COD**	**Codend type Danish + German Windows**			
Number of data sets	13				
Number of hauls	79				
Number of vessels	5				
		95%Confidence limits		Maximum	Minimum
Mean Window Selection factor	3.09	3.18	3.00	3.29	2.71
weighted by hauls	3.01				
weighted by sqrt(hauls)	3.05				
Mean Selection range cm	7.8	8.4	7.2	9.8	6.2
weighted by hauls	7.4				
weighted by sqrt(hauls)	7.7				
Mean Window selection ratio	0.69	0.73	0.64	0.81	0.54
weighted by hauls	0.64				
weighted by sqrt(hauls)	0.67				
Mean Selection factor*	3.18	3.27	3.1	3.37	2.89
weighted by hauls	3.11				
weighted by sqrt(hauls)	3.15				
Mean selection ratio*	0.71	0.76	0.66	0.86	0.56
weighted by hauls	0.67				
weighted by sqrt(hauls)	0.69				

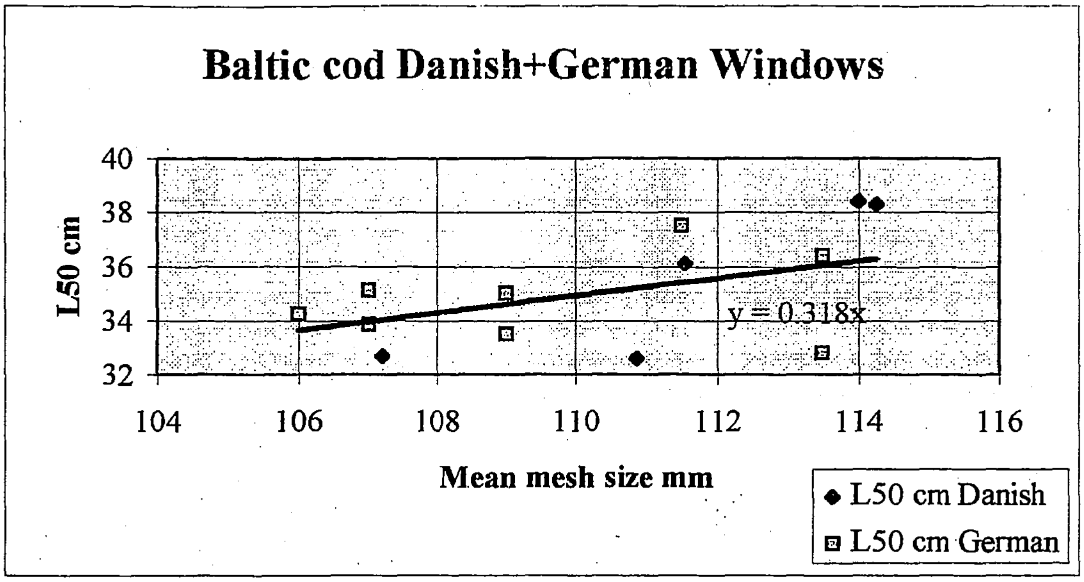
* based on mean of window and codend mesh sizes



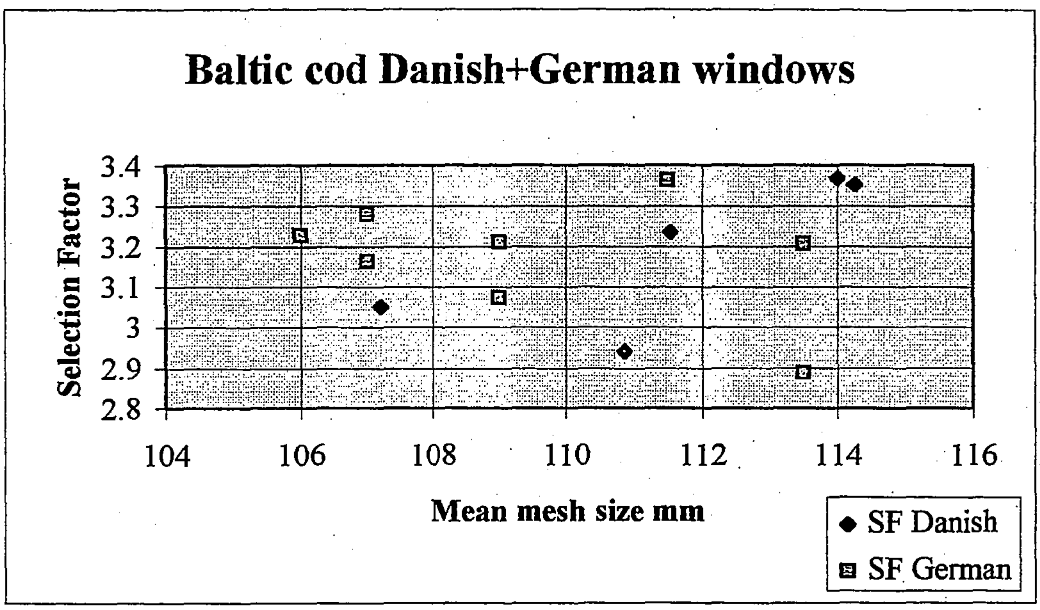
Linear regression	slope	intercept	0.173287	15.39801
L50-mesh size	se slope	se interc	0.097356	11.08747
	r squared	se yest	0.223612	1.914153
	F	df	3.168178	11
	SS regr	SS resid	11.60814	40.30378

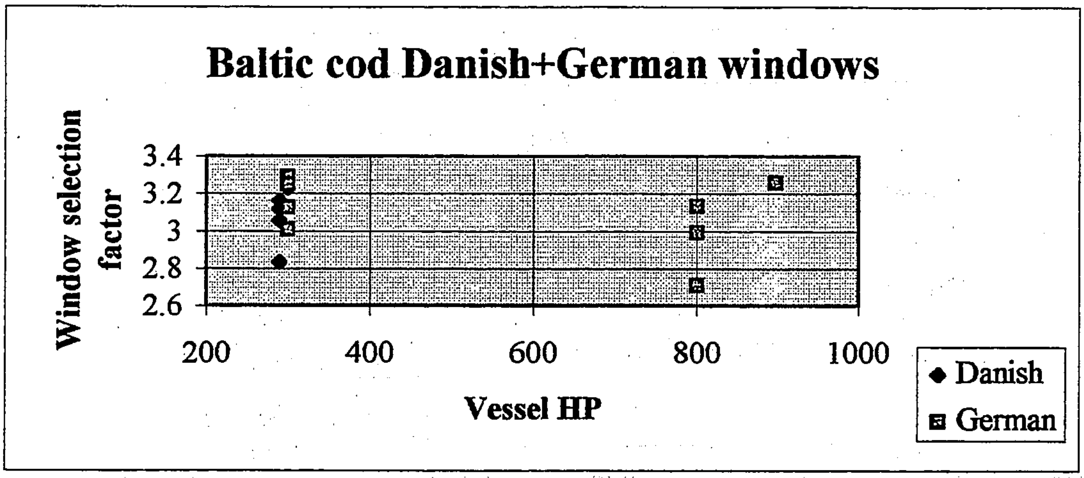
Forced through origin	slope	intercept	0.308337	0
	se slope	se interc	0.004839	#N/A
	r squared	se yest	0.087483	1.986842
	F	df	1.150445	12
	SS regr	SS resid	4.54143	47.37049

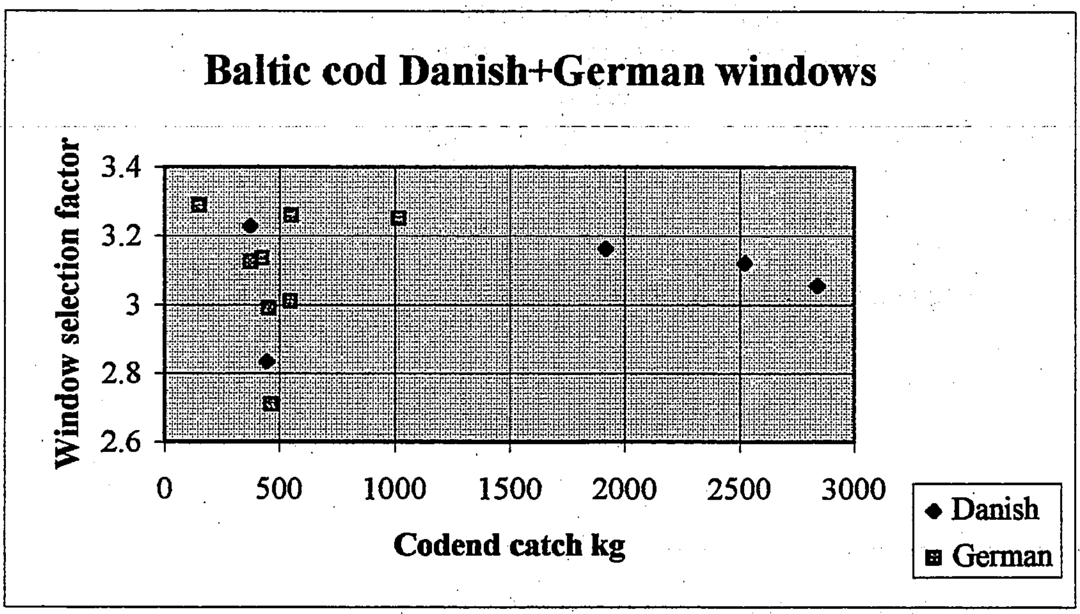


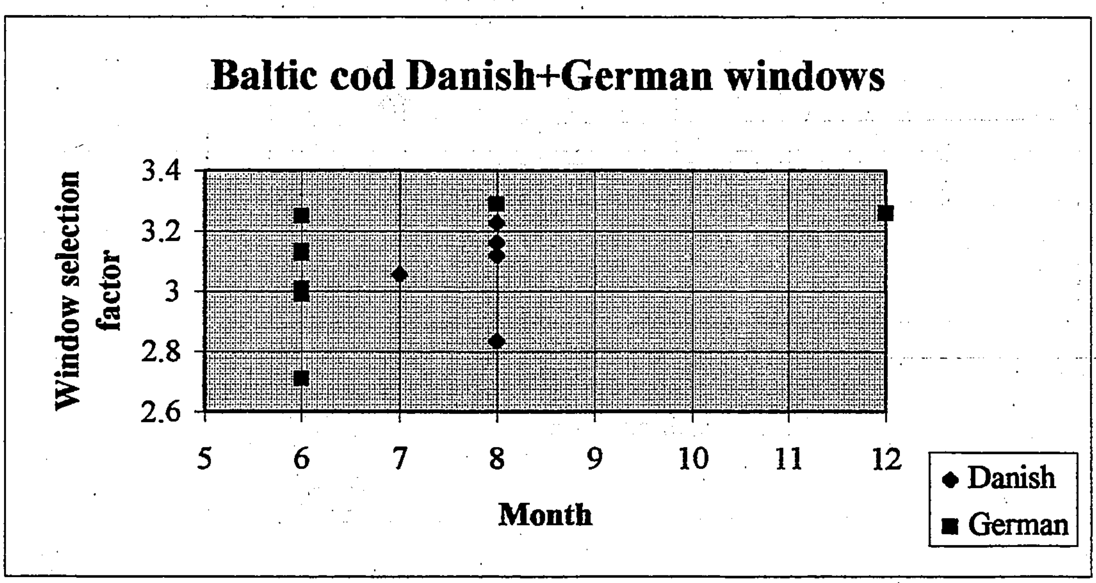


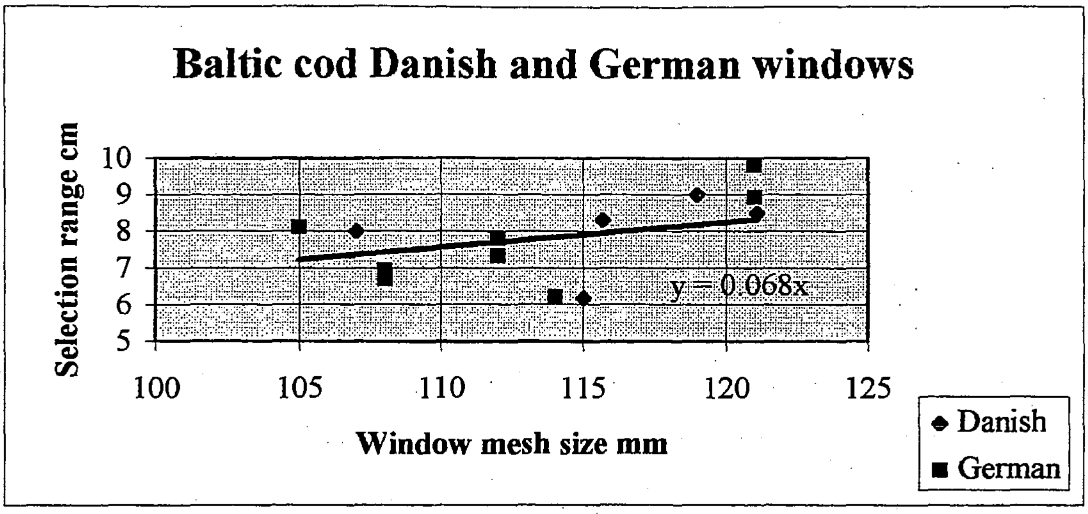
Linear regression	slope	intercept	0.394296	-8.39444
L50-mesh size	se slope	se interc	0.173919	19.19589
	r squared	se yest	0.318457	1.793428
	F	df	5.139847	11
	SS regr	SS resid	16.53171	35.38021
Forced through origin	slope	intercept	0.318266	0
	se slope	se interc	0.004352	#N/A
	r squared	se yest	0.306608	1.731938
	F	df	5.306237	12
	SS regr	SS resid	15.91663	35.99529




Baltic cod Danish+German windows
Window selection factor
3.4
3.2
3
2.8
2.6
200
400
600
800
1000
Vessel HP
Danish
German

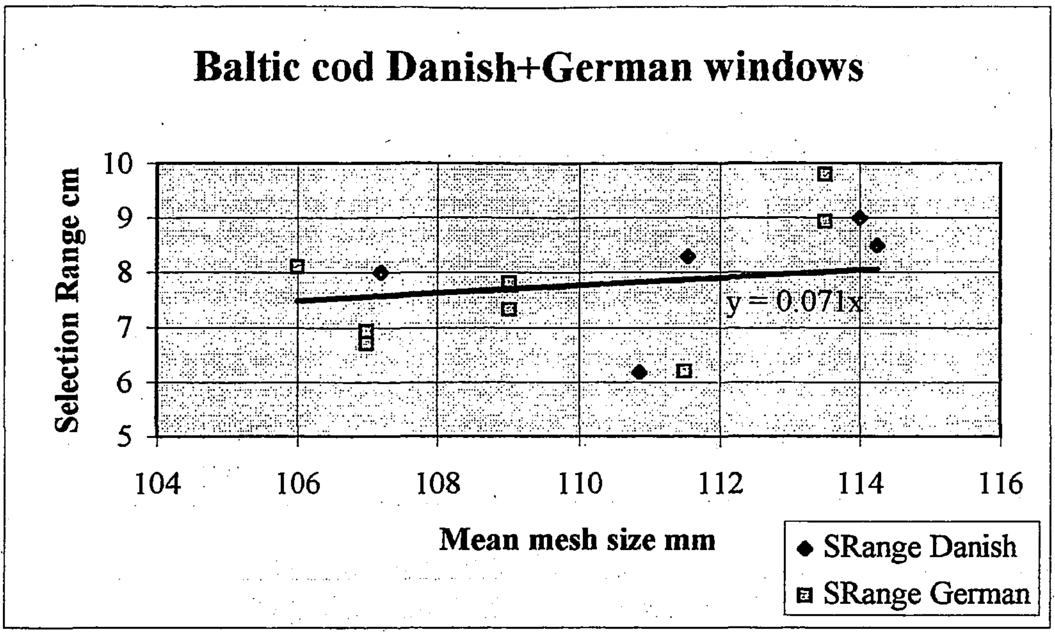

Baltic cod Danish+German windows
Window selection factor
3.4
3.2
3
2.8
2.6
0
500
1000
1500
2000
2500
3000
Codend catch kg
Danish
German


Baltic cod Danish+German windows
Window selection factor
3.4
3.2
3
2.8
2.6
5
6
7
8
9
10
11
12
Month
Danish
German



Linear regression	slope	intercept	0.066889	0.135748
L50-mesh size	se slope	se interc	0.059481	6.775693
	r squared	se yest	0.136496	1.026589
	F	df	1.264579	8
	SS regr	SS resid	1.332721	8.431082

Forced through origin	slope	intercept	0.068079	0
	se slope	se interc	0.002687	#N/A
	r squared	se yest	0.136453	0.967902
	F	df	1.422128	9
	SS regr	SS resid	1.332298	8.431505



Linear regression	slope	intercept	0.189614	-13.0931
L50-mesh size	se slope	se interc	0.097718	10.78542
	r squared	se yest	0.255005	1.007657
	F	df	3.765201	11
	SS regr	SS resid	3.823081	11.1691
Forced through origin	slope	intercept	0.071028	0
	se slope	se interc	0.002582	#N/A
	r squared	se yest	0.155196	1.027353
	F	df	2.204483	12
	SS regr	SS resid	2.32673	12.66545

Species	COD	Codend type	Standard	Sheet number	1

Reference	5	8	9	9	9	9	9	9	12	13
ICES Area	IIIa-N	IV a	IV a	IV a	IV a	IV a	IV a	IV a	IV a	IV a
Test date	Jun-92	Jun-93	Oct-94	Oct-94	Oct-94	Oct-94	Oct-94	Oct-94	Mar-95	Mar-96
Vessel nationality - type	DEN-C	DEN-C	DEN-C	DEN-C	DEN-C	DEN-C	DEN-C	DEN-C	GER-R	GER-R
Vessel HP	517	775	775	775	775	775	775	775	800	800
Gear type	SDN	OTB	OTB	OTB	OTB	OTB	OTB	OTB	OTB	OTB
Experimental method	C+2mH	C+2mH	C+2.5mH	C+2.5mH	C+2.5mH	C+2.5mH	C+2.5mH	C+2.5mH	C+SH	C+SH
Codend										
Mesh opening mm	102.3	74.9	105.6	99.1	100.5	103.0	101.6	101.6	98.4	101.2
Circumf. open meshes	88	94	100	100	100	100	100	100	100	100
Total length	8.2	4.0	5.8	5.8	5.8	5.8	5.8	5.8	15.4	20.8
Twine	4mmDb	2.5mmDb	2.5mmDb	4mmDb	5mmDb	6mmDb	4mmS	8mmS	4mmDb	4mmDb
Window type										
Mesh opening mm										
Fishing conditions										
Codend catch / haul kg	515	501	332	598	475	624	341	493	357	703
Cover catch / haul kg		995								
Towing time hours		7.3							1.7	2.0
Wind speed m/sec	4.0	6.4								
Sea state									4	3
Selectivity curve model	O-P	L-P	L-H-F	L-H-F	L-H-F	L-H-F	L-H-F	L-H-F	L-H-F	L-H-F
Valid hauls	18	11	5	5	4	6	5	4	19	19
Number in Sel. Range										
L25 cm	30.8	21.0	36.6	30.7	28.7	31.6	35.8	29.4	26.4	27.9
L50 cm	34.5	24.3	39.7	33.3	31.1	34.3	38.4	31.5	29.8	31.9
Selection factor	3.37	3.24	3.76	3.36	3.10	3.33	3.78	3.10	3.03	3.15
Selection range cm	5.8	6.7	6.3	5.2	4.8	5.5	5.3	4.2	6.9	7.9

Species	COD	Codend type	Standard	Sheet number	1

Other data										
Vessel name	Doggerbar	Tannisbug	Tannisbug	Tannisbug	Tannisbug	Tannisbug	Tannisbug	Tannisbug	Solea	Solea
L50 standard error									0.4	
L50 lower 95% con.lim.	33.5		38.3	32.0	28.0	32.6	4.1	3.6		
L50 upper 95% con.lim.	35.5		40.9	34.4	33.9	36.2	6.6	4.8		
SR standard error										
SR lower 95% con.lim.	5.3		5.1	4.4	4.3	4.6				
SR upper 95% con.lim.	6.4		7.5	6.0	5.2	6.3				
Selection ratio	0.57	0.89	0.60	0.52	0.48	0.53	0.52	0.41	0.70	0.78
Parameter a		-8.03	-13.84	-14.07	-14.23	-13.70	-15.92	-16.48	-9.49	-8.82
Parameter b		0.330	0.349	0.423	0.458	0.399	0.415	0.523	0.318	0.277
Parameter p										
Variance r11										
Variance r22										
Variance r33										
Covariance r12										
Covariance r13										
Covariance r23										
Between haul variance										
Variance d11										
Variance d22										
Variance d33										
Covariance d12										
Covariance d13										
Covariance d23										

Species	COD		Codend type	Standard		Sheet number	2

Reference	14	15	15	31						
ICES Area	IV a	IV a	IV a	IV a						
Test date	Mar-97	Mar-95	Mar-95	Aug-91						
Vessel nationality - type	GER-R	NOR-C	NOR-C	SCO-C						
Vessel HP	800	1000	1000	608						
Gear type	OTB	OTB	OTB	PTB						
Experimental method	C+SH	TR	TR	C+2.1mH						
Codend				7 different*						
Mesh opening mm	98.8	99.1	99.1	108.3						
Circumf. open meshes	100	100	100	82						
Total length	20.8/15.4	15.8	15.8	17.1						
Twine	4mmDb	4mmDb	4mmDb	4mmDb						
Window type										
Mesh opening mm										
Fishing conditions										
Codend catch / haul kg	581	411	687	1213						
Cover catch / haul kg		606	768	1593						
Towing time hours	2.3	2.5	2.5	4.0						
Wind speed m/sec										
Sea state	3									
Selectivity curve model	L-H-F	L-H-S	L-H-S	L-S-H-FF						
Valid hauls	23	10	10	11						
Number in Sel. Range										
L25 cm	28.4	30.2	31.8	33.0						
L50 cm	32.4	32.9	34.2	35.6						
Selection factor	3.28	3.32	3.45	3.29						
Selection range cm	8.1	5.3	4.9	5.2						

Species	COD		Codend type	Standard		Sheet number	2

Other data										
Vessel name	Solea	Marandi	Marandi	Constant Friend & Starlight						
L50 standard error										
L50 lower 95% con.lim.		31.5	33.1							
L50 upper 95% con.lim.		34.4	35.6							
SR standard error										
SR lower 95% con.lim.		4.5	4.2							
SR upper 95% con.lim.		6.1	5.5							
Selection ratio	0.82	0.53	0.49	0.48						
Parameter a	-8.79	-13.72	-15.47	-14.92						
Parameter b	0.271	0.418	0.452	0.419						
Parameter p		0.4650	0.5182							
Variance r11										
Variance r22										
Variance r33										
Covariance r12										
Covariance r13										
Covariance r23										
Between haul variance										
Variance d11				12.9900						
Variance d22				0.0117						
Variance d33				-0.3770						
Covariance d12										
Covariance d13										
Covariance d23										

* mean circumf 3.37m

Data Summary	COD		Codend type	Standard	
Number of data sets	14				
Number of hauls	150				
Number of vessels	5				
		95%Confidence limits		Maximum	Minimum
Mean Selection factor	3.33	3.44	3.21	3.78	3.03
weighted by hauls	3.28				
weighted by sqrt(hauls)	3.30				
Mean Selection range cm	5.9	6.5	5.2	8.1	4.2
weighted by hauls	6.4				
weighted by sqrt(hauls)	6.1				
Mean Selection ratio	0.60	0.67	0.52	0.89	0.41
weighted by hauls	0.65				
weighted by sqrt(hauls)	0.62				

Species	PLE	Codend type	Standard	Sheet number	1

Reference	6	6	34	34	34	34	34	35	35	35
ICES Area	IIIa	IIIa	IV c	IV c	IV c	IV c	IV c	IV b	IV b	IV b
Test date	May-91	May-91	Sep-81	Sep-81	Sep-81	Sep-81	Sep-81	May-91	May-91	May-91
Vessel nationality - type	DEN-C	DEN-C	NED-C	NED-C	NED-C	NED-C	NED-C	NED-C	NED-C	NED-C
Vessel HP	517	517	1310	1310	1310	1310	1310	1015	1015	1015
Gear type	SDN	SDN	TBB	TBB	TBB	TBB	TBB	TBB	TBB	TBB
Experimental method	TR	TR	C+Fl	C+Fl	C+Fl	C+Fl	C+Fl	C+Fl	C+Fl	C+Fl
Codend										
Mesh opening mm	100.9	100.9	123.1	112.2	126.0	112.2	127.5	94.0	113.5	127.2
Circumf. open meshes	100	80								
Total length	10.0	4.1								
Twine	4mmDb	4mmDb								
Window type										
Mesh opening mm										
Fishing conditions										
Codend catch / haul kg			68	208	16	92	40	276	212	192
Cover catch / haul kg			512	352	36	180	212	276	212	368
Towing time hours			2.1	2.0	0.3	1.0	1.0	1.2	1.2	1.2
Wind speed m/sec										
Sea state										
Selectivity curve model	L-P-S	L-P-S								
Valid hauls	5	8	4	7	7	2	2	24	26	24
Number in Sel. Range	631	305	827	1056	238	185	241	1284	9305	6640
L25 cm	25.3	25.6	26.5	23.4	26.1	23.5	27.5	17.4	21.2	22.6
L50 cm	27.2	27.5	27.8	24.7	28.0	25.0	29.0	19.0	22.9	25.4
Selection factor	2.70	2.73	2.26	2.20	2.22	2.23	2.27	2.02	2.02	2.00
Selection range cm	3.8	3.8	2.6	2.6	3.8	3.0	3.1	3.2	3.5	5.6

Species	PLE		Codend type	Standard		Sheet number	1

Other data										
Vessel name	Doggerbank	Doggerbank								
L50 standard error										
L50 lower 95% con.lim.										
L50 upper 95% con.lim.										
SR standard error										
SR lower 95% con.lim.										
SR upper 95% con.lim.										
Selection ratio	0.38	0.38	0.21	0.23	0.30	0.27	0.24	0.34	0.31	0.44
Parameter a	-15.73	-15.90	-23.49	-20.87	-16.19	-18.31	-20.55	-13.04	-14.37	-9.96
Parameter b	0.578	0.578	0.845	0.845	0.578	0.732	0.709	0.687	0.628	0.392
Parameter p	0.5820	0.6230								
Variance r11										
Variance r22										
Variance r33										
Covariance r12										
Covariance r13										
Covariance r23										
Between haul variance										
Variance d11										
Variance d22										
Variance d33										
Covariance d12										
Covariance d13										
Covariance d23										

Species	PLE

Codend type	Standard

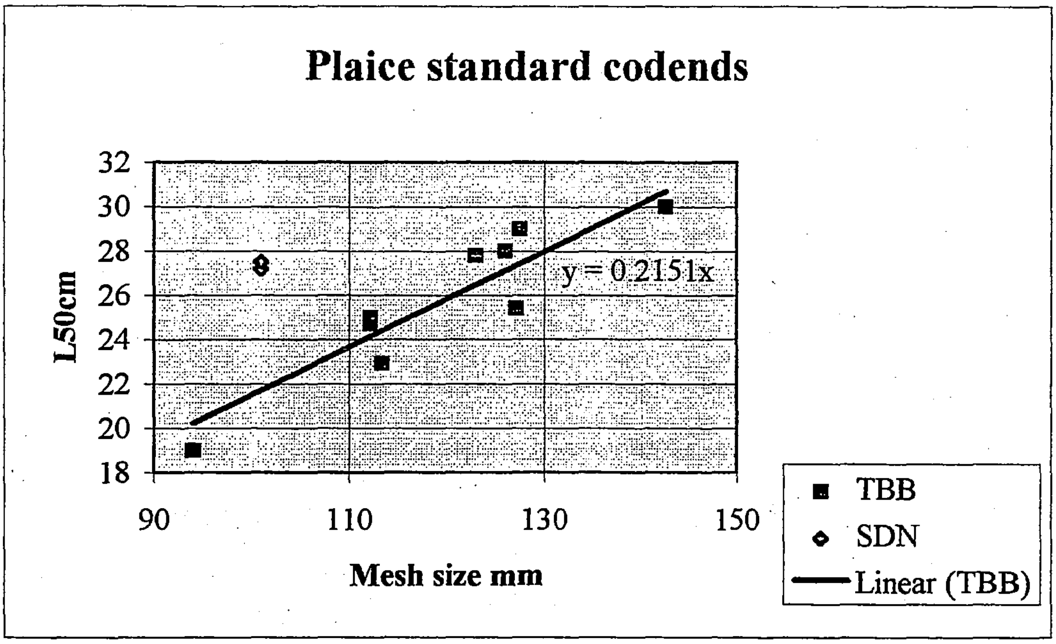
Sheet number	2

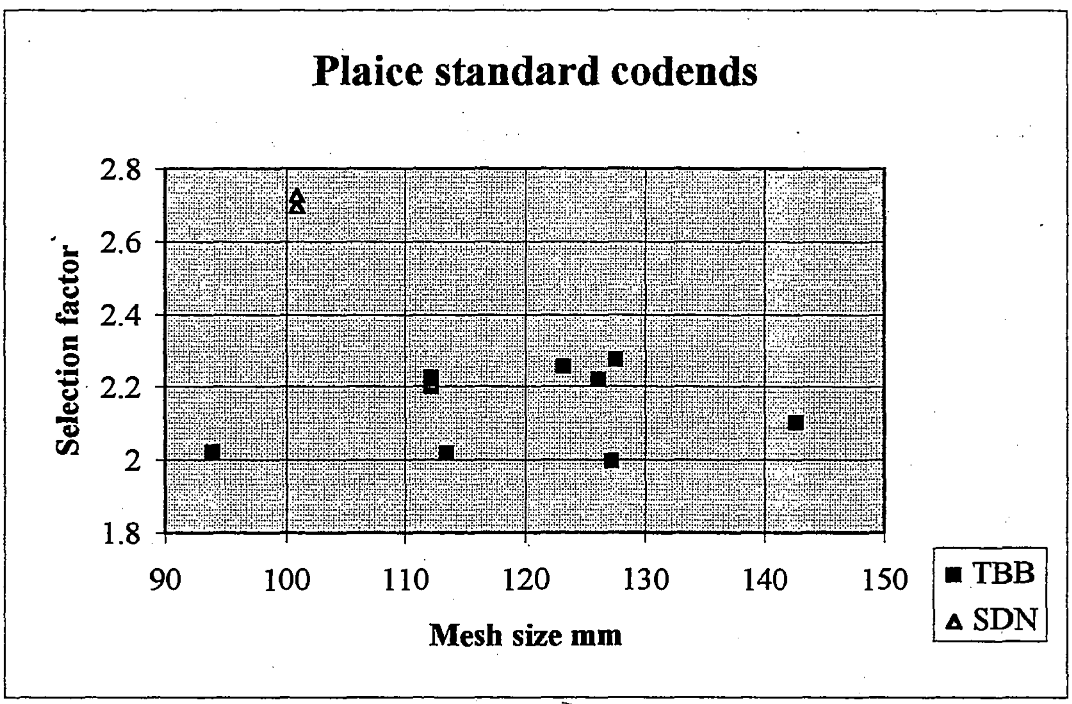
Reference	35											
ICES Area	IV b											
Test date	May-91											
Vessel nationality - type	NED-C											
Vessel HP	1015											
Gear type	TBB											
Experimental method	C+Fl											
Codend												
Mesh opening mm	142.7											
Circumf. open meshes												
Total length												
Twine												
Window type												
Mesh opening mm												
Fishing conditions												
Codend catch / haul kg	84											
Cover catch / haul kg	412											
Towing time hours	1.2											
Wind speed m/sec												
Sea state												
Selectivity curve model												
Valid hauls	20											
Number in Sel. Range	2453											
L25 cm	27.3											
L50 cm	30.0											
Selection factor	2.10											
Selection range cm	5.4											

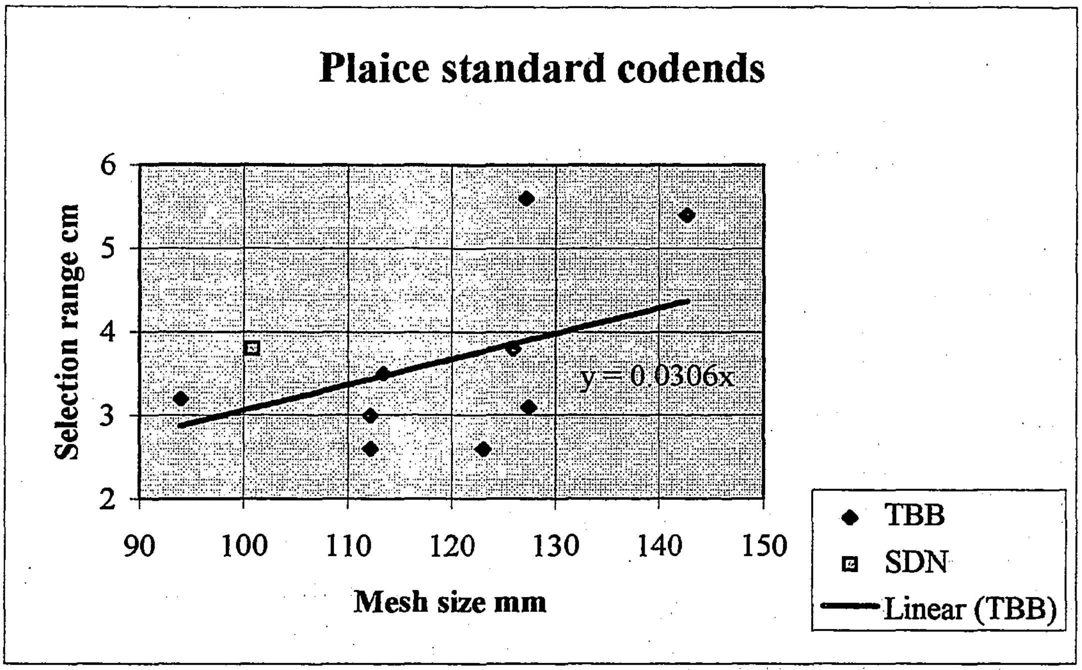
Species	PLE	Codend type	Standard	Sheet number	2

Other data										
Vessel name										
L50 standard error										
L50 lower 95% con.lim.										
L50 upper 95% con.lim.										
SR standard error										
SR lower 95% con.lim.										
SR upper 95% con.lim.										
Selection ratio	0.38									
Parameter a	-12.21									
Parameter b	0.407									
Parameter p										
Variance r11										
Variance r22										
Variance r33										
Covariance r12										
Covariance r13										
Covariance r23										
Between haul variance										
Variance d11										
Variance d22										
Variance d33										
Covariance d12										
Covariance d13										
Covariance d23										

Data Summary	PLE	Codend type		Standard	
Number of data sets	11				
Number of hauls	129				
Number of vessels	3				
		95%Confidence limits		Maximum	Minimum
Mean Selection factor	2.25	2.40	2.10	2.73	2.00
weighted by hauls	2.13				
weighted by sqrt(hauls)	2.19				
Mean Selection range cm	3.7	4.3	3.1	5.6	2.6
weighted by hauls	4.1				
weighted by sqrt(hauls)	3.9				
Mean Selection ratio	0.32	0.36	0.27	0.44	0.21
weighted by hauls	0.35				
weighted by sqrt(hauls)	0.33				

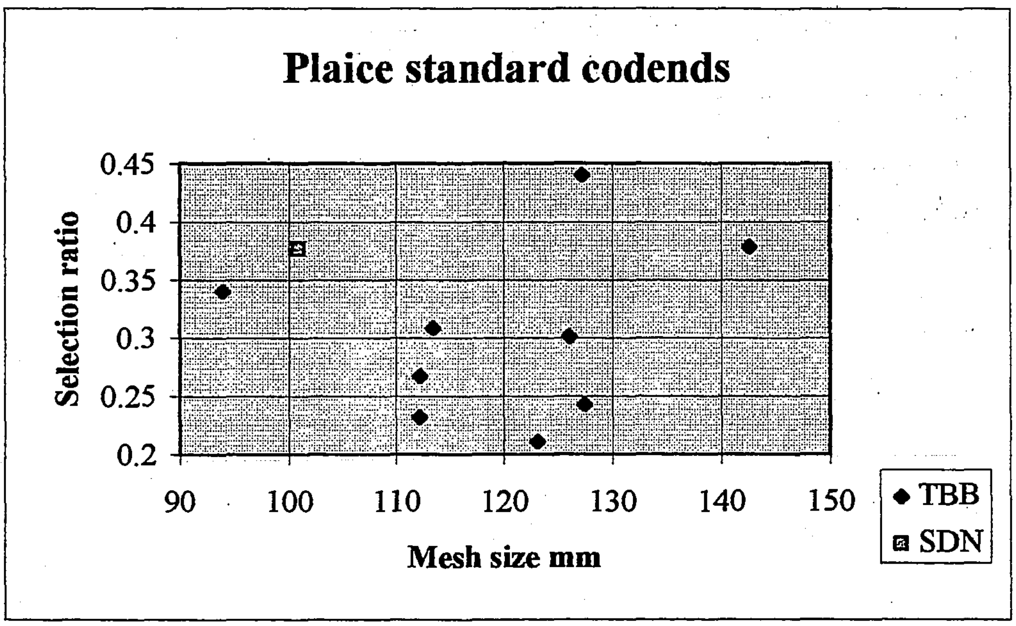

Plaice standard codends
32
30
28
26
24
22
20
18
L50cm
90
110
130
150
Mesh size mm
y = 0.2151x
TBB
SDN
Linear (TBB)


Plaice standard codends
2.8
2.6
2.4
2.2
2
1.8
Selection factor
90
100
110
120
130
140
150
Mesh size mm
TBB
SDN



Linear regression	slope	intercept	0.032607	-0.12239
SRange-mesh size	se slope	se interc	0.020413	2.392531
TBB + SDN	r squared	se yest	0.220881	0.934222
	F	df	2.551514	9
	SS regr	SS resid	2.226886	7.854933

Forced through origin	slope	intercept	0.03157	0
TBB + SDN	se slope	se interc	0.00228	#N/A
	r squared	se yest	0.220655	0.886409
	F	df	2.831284	10
	SS regr	SS resid	2.224602	7.857217



Species	NEP	Codend type	Standard	Sheet number	1

Reference	7	7	7	7	7	7	7	7	7	8
ICES Area	IV a	IIIa	IV a	IV a	IIIa	IV a	IV a	IV a	IV a	IV a
Test date	Jun-93	Mar-93	Jun-93	Jun-93	Mar-93	Jun-93	Jun-93	Jun-93	Jun-93	Jun-93
Vessel nationality - type	DEN-C	DEN-C	DEN-C	DEN-C	DEN-C	DEN-C	DEN-C	DEN-C	DEN-C	DEN-C
Vessel HP	775	775	775	775	775	775	775	775	775	775
Gear type	TBN	TBN	TBN	TBN	TBN	TBN	OTB	OTB	OTB	OTB
Experimental method	C+2mH	C+2mH	C+2mH	C+2mH	C+2mH	C+2mH	C+2mH	C+2mH	C+2mH	C+2mH
Codend										
Mesh opening mm	74.9	73.2	76.5	83.8	85.7	86.0	111.2	110.0	111.3	73.2
Circumf. open meshes	100	122	143	82	100	118	70	85	100	94
Total length	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	4.0
Twine	4mmS	4mmS	4mmS	4mmDb	4mmDb	4mmDb	4mmDb	4mmDb	4mmDb	2.5mmDb
Window type										
Mesh opening mm										
Fishing conditions										
Codend catch / haul kg										456
Cover catch / haul kg										920
Towing time hours	4.0	3.8	4.2	6.9	4.5	6.9	3.9	4.1	4.8	10.2
Wind speed m/sec										8.9
Sea state										
Selectivity curve model	L-H-FF	L-H-FF	L-H-FF	L-H-FF	L-H-FF	L-H-FF	L-H-FF	L-H-FF	L-H-FF	C-H-F
Valid hauls	5	6	5	2	3	2	4	5	3	4
Number in Sel. Range	9273	3271	977	16753	7883	11286	1259	1845	4441	12500
L25 mm	21.7	21.9	17.2	18.3	18.6	13.8	33.4	33.6	28.8	28.6
L50 mm	28.4	26.1	24.5	30.3	28.0	26.4	43.6	41.3	39.7	37.3
Selection factor	0.38	0.36	0.32	0.36	0.33	0.31	0.39	0.38	0.36	0.51
Selection range mm	13.6	8.4	14.7	23.9	18.7	25.1	20.5	15.4	21.7	15.7

Species	NEP		Codend type	Standard		Sheet number	1

Other data										
Vessel name	Tannisbugt	Tannisbugt	Tannisbugt	Tannisbugt	Tannisbugt	Tannisbugt	Tannisbugt	Tannisbugt	Tannisbugt	Tannisbugt
L50 standard error										
L50 lower 95% con.lim.										32.0
L50 upper 95% con.lim.										41.8
SR standard error										
SR lower 95% con.lim.										13.4
SR upper 95% con.lim.										18.1
Selection ratio	0.18	0.11	0.19	0.28	0.22	0.29	0.18	0.14	0.20	0.21
Parameter a	-4.61	-6.84	-3.65	-2.79	-3.28	-2.31	-4.67	-5.90	-4.01	-4.10
Parameter b	0.162	0.262	0.149	0.092	0.117	0.088	0.107	0.143	0.101	0.100
Parameter p										
Variance D11										
Variance D22										
Variance D33										
Covariance D12										
Covariance D13										
Covariance D23										
Between haul variance										
Variance d11										
Variance d22										
Variance d33										
Covariance d12										
Covariance d13										
Covariance d23										

Species	**NEP**	**Codend type**	**Standard**	**Sheet number**	**2**

Reference	17	17	22	26	26	27			25	25
ICES Area	VI a	VI a	IIIa	IV bc	IV bc	IIIa			IV a	IV a
Test date	Aug-96	Aug-96	May-91	Jun-93	Jun-93	Jul-Nov 88			May-92	May-92
Vessel nationality - type	SCO-C	SCO-C	SWE-C	BEL-C	BEL-C	DEN-C			SCO-C	SCO-C
Vessel HP	550	550	544	375	375				550	550
Gear type	TBN	TBN	TBN	TBN	TBN	TBN			TBN	TBN
Experimental method	C+2.5mH	C+2.5mH	TW	C+Fl	C+Fl	TW-CF			TW-FTS	TW-FTS
Codend										
Mesh opening mm	69.4	96.0	71.3	70.0	82.2	65.0			68.7	80.8
Circumf. open meshes	100	100	100-?	90	90				106	106
Total length	6+?	5.8+?	12.0	4.0	4.9				12.1	12.1
Twine	4mmDb	4mmDb	3mmS	?mmS	?mmDb				3.5mmS	3.5mmS
Window type										
Mesh opening mm										
Fishing conditions										
Codend catch / haul kg	227	373				150				
Cover catch / haul kg	27	64								
Towing time hours	1.5	1.9	3.5	3.5	3.5	6.0			3.9	2.9
Wind speed m/sec	4.5	3.9								
Sea state	2	2								
Selectivity curve model	L-P	L-H-F	N-P-IR	C-H-F	C-H-F	L-P-IE			L-H-S	L-H-S
Valid hauls	8	8	10	23	9	54			6	5
Number in Sel. Range			3421							
L25 mm	15.7	18.6	21.2	24.4	20.4	24.3			19.8	22.2
L50 mm	21.5	27.3	26.5	31.9	28.9	31.2			24.4	24.7
Selection factor	0.31	0.28	0.37	0.46	0.35	0.48			0.35	0.31
Selection range mm	11.7	17.4	10.7	14.8	16.8	13.9			9.3	5.1

Species	NEP	Codend type	Standard	Sheet number	2

Other data										
Vessel name	Heather Sp	Heather Sp	Rokard	Gleaner	Gleaner	7 different			Heather Sp	Heather Sp
L50 standard error										
L50 lower 95% con.lim.	20.1									
L50 upper 95% con.lim.	22.7									
SR standard error										
SR lower 95% con.lim.	10.3									
SR upper 95% con.lim.	13.2									
Selection ratio	0.17	0.18	0.15	0.21	0.20	0.21			0.14	0.06
Parameter a	-4.04	-3.45	-5.44	-3.76	-3.07	-4.93			-5.76	-10.64
Parameter b	0.188	0.127	0.205	0.106	0.094	0.158			0.236	0.431
Parameter p										
Variance r11										
Variance r22										
Variance r33										
Covariance r12										
Covariance r13										
Covariance r23										
Between haul variance										
Variance d11										
Variance d22										
Variance d33										
Covariance d12										
Covariance d13										
Covariance d23										

Species	NEP

Codend type	Window

Sheet number	1

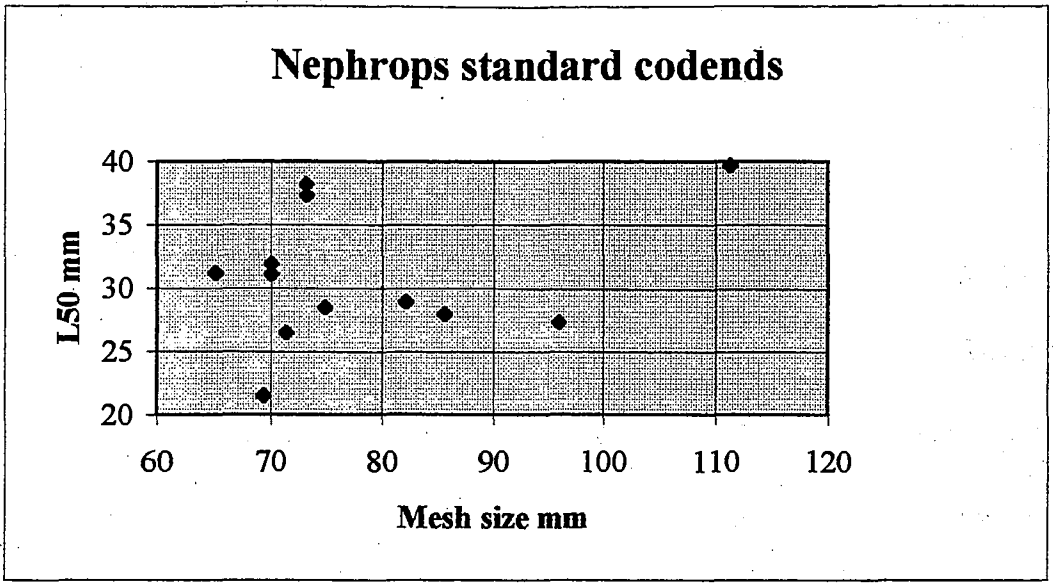
Reference	8	26								
ICES Area	IV a	IV bc								
Test date	Jun-93	Jun-93								
Vessel nationality - type	DEN-C	BEL-C								
Vessel HP	775	375								
Gear type	OTB	TBN								
Experimental method	C+2mH	C+Fl								
Codend										
Mesh opening mm	73.2	70.0								
Circumf. open meshes	94	90								
Total length	4.0	4.0								
Twine	2.5mmDb	?mmS								
Window type	UK	UK								
Mesh opening mm	92.9	70.0								
Fishing conditions										
Codend catch / haul kg	359									
Cover catch / haul kg	886									
Towing time hours	10.2	3.5								
Wind speed m/sec	8.9									
Sea state										
Selectivity curve model	C-H-F	C-H-F								
Valid hauls	4	12								
Number in Sel. Range	12500									
L25 mm	30.0	23.2								
L50 mm	38.2	31.1								
Selection factor	0.52	0.44								
Selection range mm	14.9	16.1								

Species	**NEP**	**Codend type**	**Window**	**Sheet number**	**1**

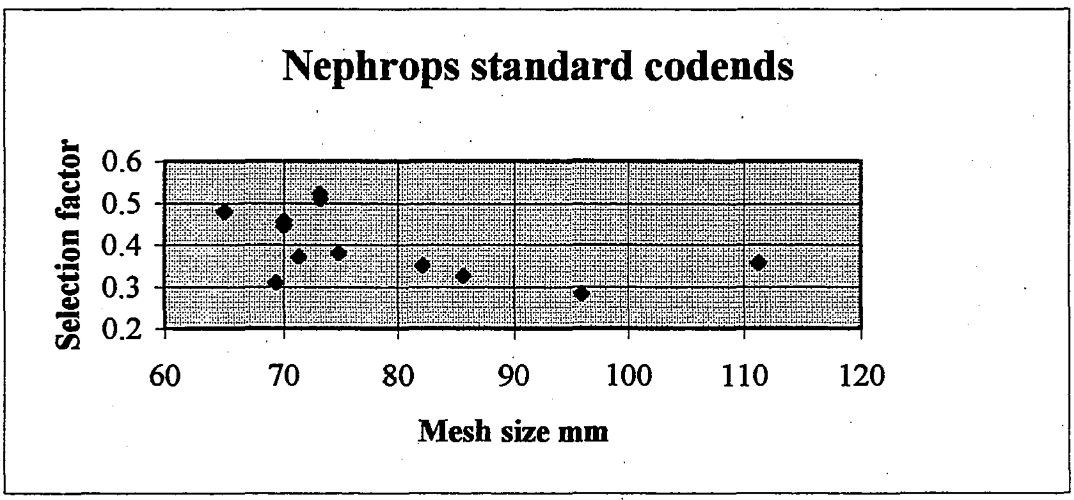
Other data										
Vessel name	Tannisbug	Gleaner								
L50 standard error										
L50 lower 95% con.lim.	33.9									
L50 upper 95% con.lim.	42.0									
SR standard error										
SR lower 95% con.lim.	11.8									
SR upper 95% con.lim.	18.0									
Selection ratio	0.20	0.23								
Parameter a	-4.40	-3.41								
Parameter b	0.106	0.098								
Parameter p										
Variance r11										
Variance r22										
Variance r33										
Covariance r12										
Covariance r13										
Covariance r23										
Between haul variance										
Variance d11										
Variance d22										
Variance d33										
Covariance d12										
Covariance d13										
Covariance d23										

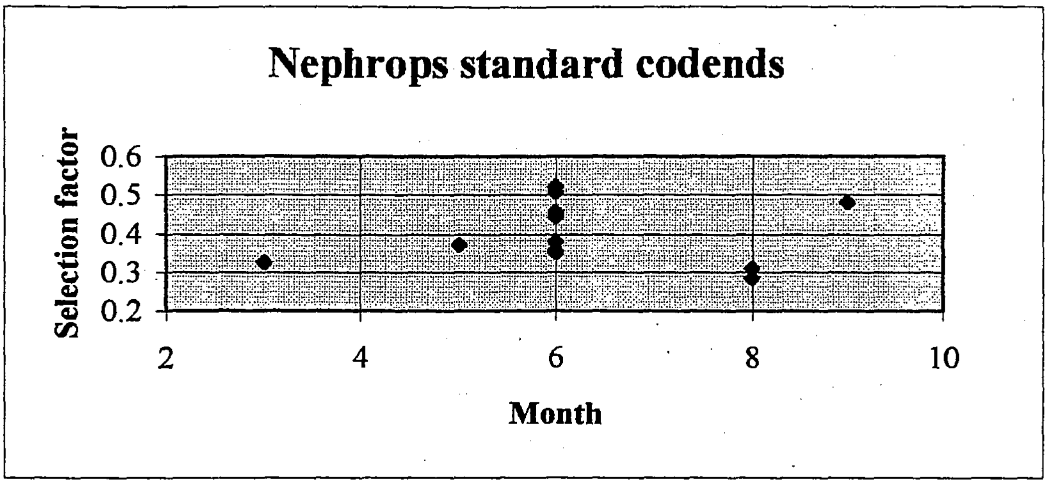
Data Summary	**NEP**	**Codend type Standard+Window**			
CODEND SELECTIVITY					
Number of data sets	12				
Number of hauls	167				
Number of vessels	11				
		95%Confidence limits		Maximum	Minimum
Mean selection factor	0.40	0.44	0.35	0.52	0.28
weighted by hauls	0.42				
weighted by sqrt(hauls)	0.41				
Mean selection range mm	15.5	17.2	13.8	21.7	10.7
weighted by hauls	15.0				
weighted by sqrt(hauls)	15.3				
Mean selection ratio	0.198	0.211	0.184	0.230	0.150
weighted by hauls	0.202				
weighted by sqrt(hauls)	0.199				

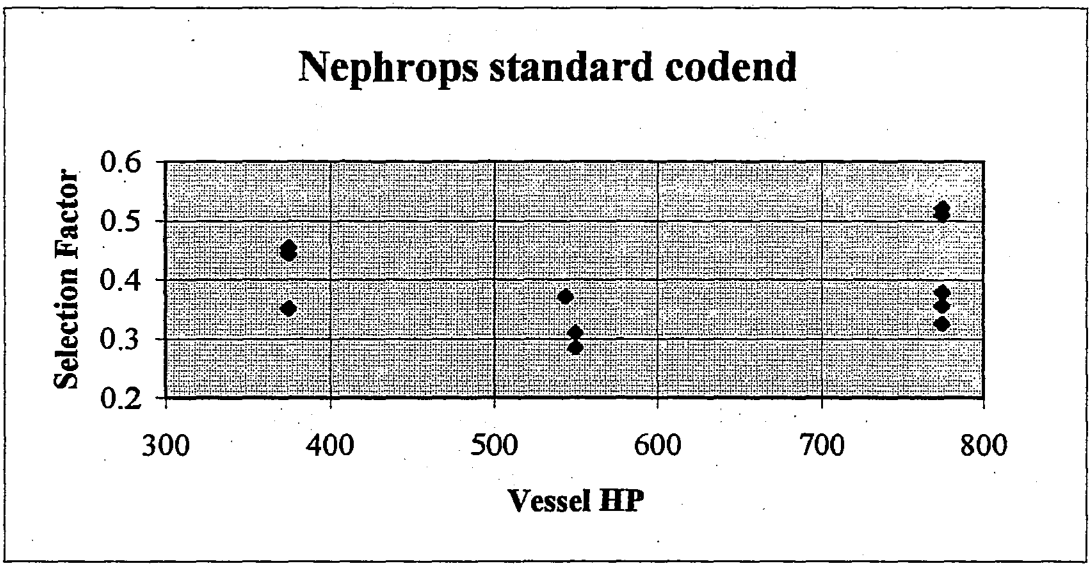
Note: In the first 9 original data sets 3 different codend circumferences were tested for each codend mesh size. These have been combined to give one data set for each mesh size at the normal commercial circumference of 100 open meshes.

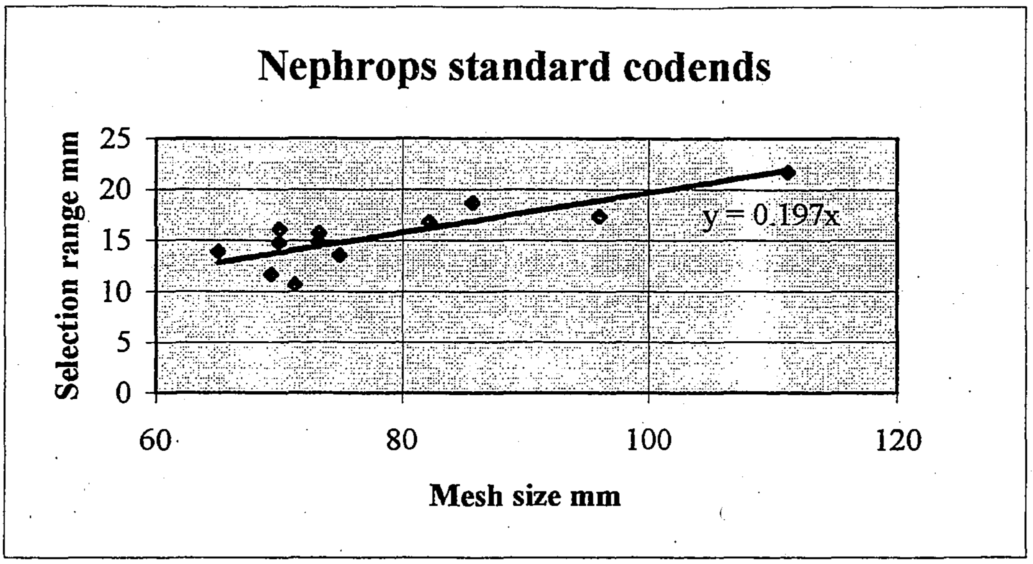


Linear regression	slope	intercept	0.119584	21.44378
L50-mesh size	se slope	se interc	0.11992	9.539655
	r squared	se yest	0.090447	5.3282
	F	df	0.994406	10
	SS regr	SS resid	28.2309	283.8971




Nephrops standard codends
Selection factor
0.6
0.5
0.4
0.3
0.2
2
4
6
8
10
Month


Nephrops standard codend
Selection Factor
0.6
0.5
0.4
0.3
0.2
300
400
500
600
700
800
Vessel HP



Linear regression	slope	intercept	0.184815	0.985768
L50-mesh size	se slope	se interc	0.040142	3.193303
	r squared	se yest	0.679458	1.783561
	F	df	21.19717	10
	SS regr	SS resid	67.4301	31.81089

Forced through origin	slope	intercept	0.197045	0
	se slope	se interc	0.0062	#N/A
	r squared	se yest	0.676404	1.708642
	F	df	22.99296	11
	SS regr	SS resid	67.12696	32.11403

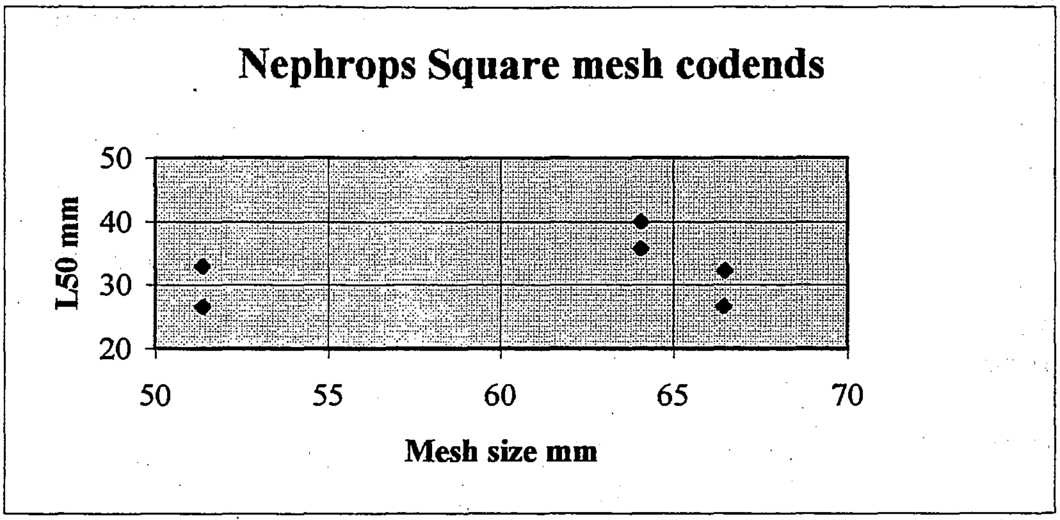
Species	NEP		Codend type	Square mesh			Sheet number	1

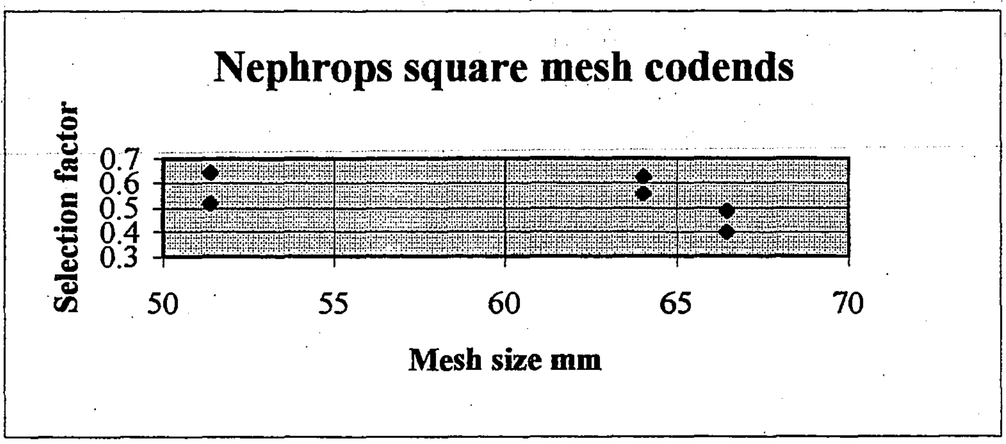
Reference	16	22	23	23	24	23			
ICES Area	VI a	IIIa	IIIa	IIIa	IIIa	IIIa			
Test date	Aug-96	May-91	Sep-93	Apr-93	Jan-96	Jun-94			
Vessel nationality - type	SCO-C	SWE-C	SWE-C	SWE-R	SWE-C	NOR-R			
Vessel HP	550	544	544	544	270	1500			
Gear type	TBN	TBN	TBN	TBN	TBN	TBN			
Experimental method	C+2.5mH	TW	DIV	DIV	TW	TW			
Codend									
Mesh opening mm	66.4	64.1	51.4	51.4	66.5	64.1			
Circumf. open meshes	92	96	80-?	80-?	96	96			
Total length	6+?	12.0	6.5+?	6.5+?	8.0+?	8.0			
Twine	4mmS	2.5mmS	1.8mmS	1.8mmS	2.5mmS	2.5mmS			
Window type									
Mesh opening mm									
Fishing conditions									
Codend catch / haul kg	266		248			15			
Cover catch / haul kg	37		296			25			
Towing time hours	1.7	3.5							
Wind speed m/sec	3.9								
Sea state	1								
Selectivity curve model	L-H-F	N-P-IR	L-P	L-P	L-P	L-P			
Valid hauls	14	11	9	7	24	6			
Number in Sel. Range		10824	9515	1088		802			
L25 mm	20.9	32.8	20.3	28.4	26.4	27.3			
L50 mm	26.6	40.0	26.6	33.0	32.3	35.7			
Selection factor	0.40	0.62	0.52	0.64	0.49	0.56			
Selection range mm	11.5	14.5	12.7	9.3	11.9	16.9			

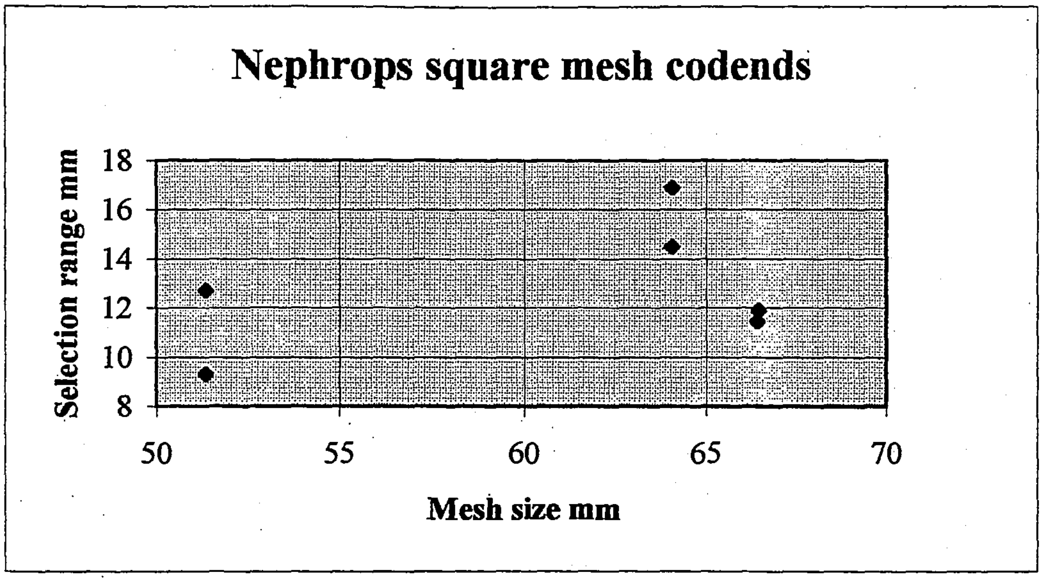
Species	NEP		Codend type	Square mesh		Sheet number	1

Other data										
Vessel name	Heather S	Rokard		Ancylus	Naamy	M. Sars				
L50 standard error										
L50 lower 95% con.lim.										
L50 upper 95% con.lim.										
SR standard error										
SR lower 95% con.lim.										
SR upper 95% con.lim.										
Selection ratio	0.17	0.23	0.25	0.18	0.18	0.26				
Parameter a	-5.10		-4.60	-7.80	-5.96	-4.64				
Parameter b	0.192		0.173	0.236	0.185	0.130				
Parameter p										
Variance r11										
Variance r22										
Variance r33										
Covariance r12										
Covariance r13										
Covariance r23										
Between haul variance										
Variance d11										
Variance d22										
Variance d33										
Covariance d12										
Covariance d13										
Covariance d23										

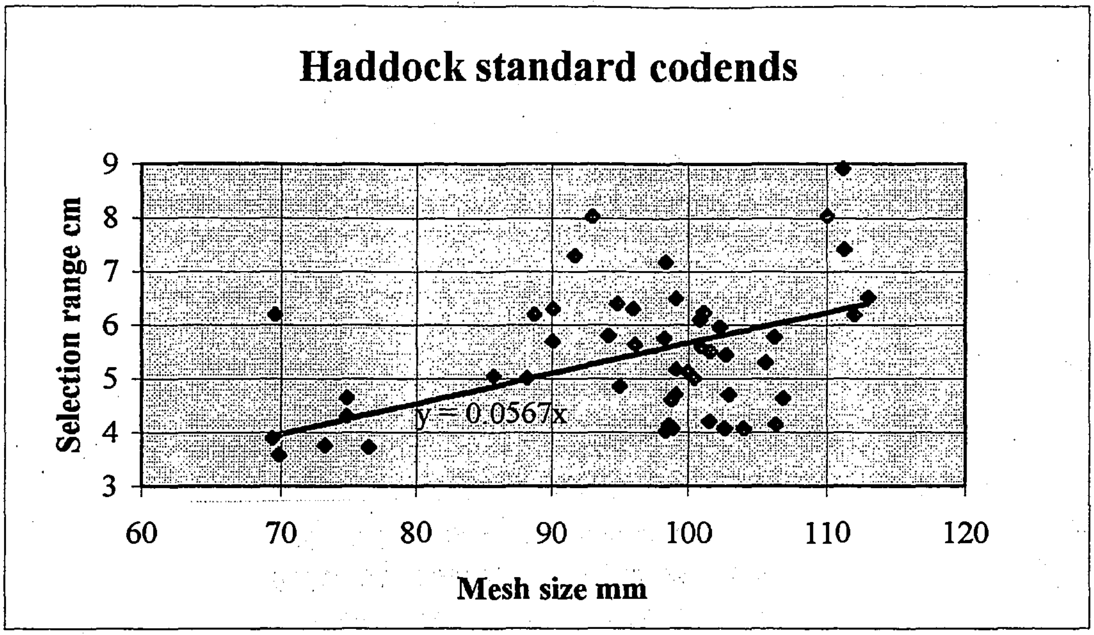
Data Summary	**NEP**		**Codend type**	**Square mesh**	
Number of data sets	6				
Number of hauls	71				
Number of vessels	6				
		95%Confidence limits		Maximum	Minimum
Mean Selection factor	0.54	0.61	0.47	0.64	0.40
weighted by hauls	0.52				
weighted by sqrt(hauls)	0.53				
Mean Selection range mm	12.8	14.9	10.7	16.9	9.3
weighted by hauls	12.5				
weighted by sqrt(hauls)	12.6				
Mean selection ratio	0.212	0.243	0.180	0.264	0.172
weighted by hauls	0.201				
weighted by sqrt(hauls)	0.206				


Nephrops Square mesh codends
L50 mm
50
40
30
20
50
55
60
65
70
Mesh size mm


Nephrops square mesh codends
Selection factor
0.7
0.6
0.5
0.4
0.3
50
55
60
65
70
Mesh size mm

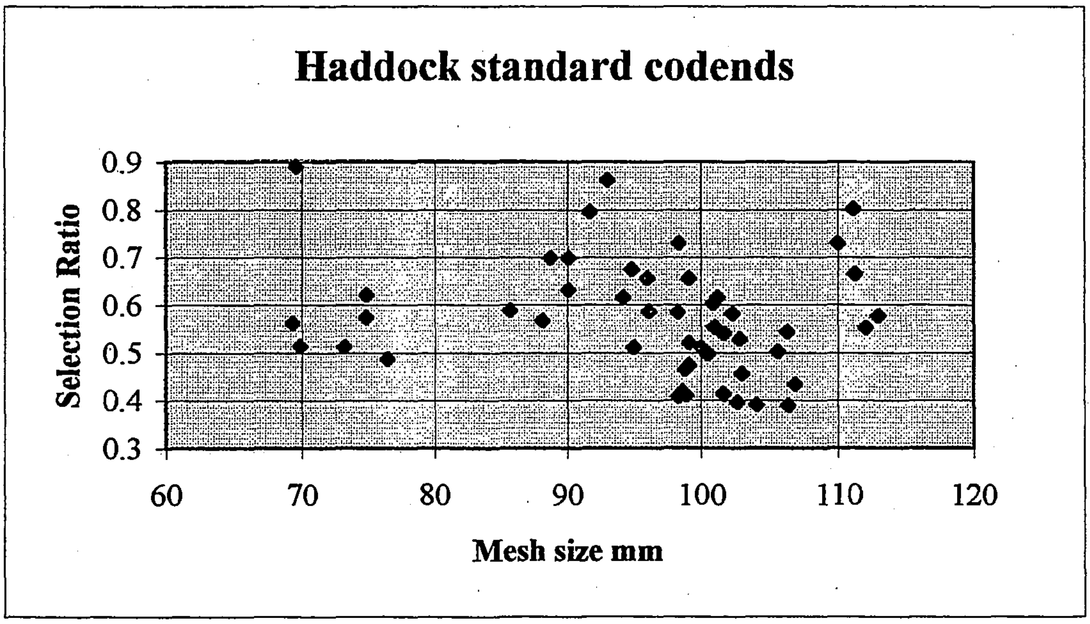


Linear regression	slope	intercept	0.152959	3.518006
SR-mesh size	se slope	se interc	0.164609	10.03919
	r squared	se yest	0.177541	2.666954
	F	df	0.863463	4
	SS regr	SS resid	6.141505	28.45058
Forced through origin	slope	intercept	0.210302	0
	se slope	se interc	0.016211	#N/A
	r squared	se yest	0.152291	2.421735
	F	df	0.898253	5
	SS regr	SS resid	5.268077	29.32401



Linear regression	slope	intercept	0.040914	1.536579
SRange-mesh size	se slope	se interc	0.014579	1.409436
	r squared	se yest	0.14352	1.158387
	F	df	7.875779	47
	SS regr	SS resid	10.56819	63.06739

Forced through origin	slope	intercept	0.056699	0
	se slope	se interc	0.001715	#N/A
	r squared	se yest	0.121861	1.16066
	F	df	6.661058	48
	SS regr	SS resid	8.973315	64.66227



Appendix 3

Towed gear selectivity measurements: Sole

Species: SOL Gear Type : TBB Sheet nr: 1.

		1	2	3	4	5	6
Author	:	Beek	Beek	Beek	Beek	Beek	Beek
Source	:	1981b	1981b	1981b	1981b	1981b	1981b
ICES Area	:	IV	IV	IV	IV	IV	IV
Test Date	:	10-1979	11-1979	11-1979	11-1979	11-1979	12-1979
Vessel Type	:	C	C	C	C	C	C
Vessel HP	:	1235	1235	1235	1235	1235	1235
Towing Speed (kn)	:	5	5	5	5	5	5
Test Method	:	P	P	P	P	P	P
Nr Hauls	:	12	26	16	15	19	17
Av.duration (min)	:	23	52	75	74	123	113
Mesh Size (mm)	:	81	80.1	82.9	101.3	80.3	86.5
Codend Material	:	PA	PA	PA	PA	PA	PA
Single/Double	:	D	D	D	S	D	D
Twine Code	:						
Twine Diam(mm)	:						
Meshes Round+Selv.	:	100	100	100	90	100	100
Open Meshes	:	76	76	76	66	76	76
Length Codend(m)	:	4.8	4.75	4.9	5.2	4.8	5.1
Length Extension(m)	:						
50% length (mm)	:	256	254	249	301	260	291
Selection Factor	:	3.16	3.17	3.00	2.97	3.24	3.36
Selection Range (mm)	:	50	27	42	41	46	43
Selection Ratio	:	0.62	0.34	0.51	0.40	0.57	0.50
Number in Selection Range: Codend	:						
Number in Selection Range: Cover	:						
Number in Selection Range: Total	:	115	61	57	184	149	585
Total Number Caught: Codend	:						
Total Number Caught: Cover	:						
Total Number Caught: Total	:	346	644	593	557	772	1458
Av.Total Catch Weight (kg): Codend	:	252	72	192	176	272	288
Av.Total Catch Weight (kg): Cover	:	388	116	324	260	336	340
Av.Total Catch Weight (kg): Total	:	640	188	516	436	608	628

Species: SOL Gear Type : TBB Sheet nr: 2.

		7	8	9	10	11	12
Author	:	Beek	Beek	Beek	Beek	Beek	Beek
Source	:	1981b	1983	1983	1983	1983	1983
ICES Area	:	IV	IVc	IVc	IVc	IVc	IVc
Test Date	:	12-1979	8-1981	8-1981	8-1981	8-1981	8-1981
Vessel Type	:	C	C	C	C	C	C
Vessel HP	:	1235	1015	1015	1015	1015	1015
Towing Speed (kn)	:	5	5.25	5.25	5.25	5.25	5.25
Test Method	:	P	C	C	C	C	C
Nr Hauls	:	15	19	8	13	12	11
Av.duration (min)	:	60	127	119	64	65	133
Mesh Size (mm)	:	83.9	81.4	68.9	81.7	69.2	93.7
Codend Material	:	PA	PA	PA	PA	PA	PA
Single/Double	:	D	D	D	D	D	D
Twine Code	:						
Twine Diam(mm)	:						
Meshes Round+Selv.	:	100					
Open Meshes	:	76					
Length Codend(m)	:	4.95					
Length Extension(m)	:						
50% length (mm)	:	279	290	236	281	239	330
Selection Factor	:	3.33	3.56	3.43	3.44	3.45	3.52
Selection Range (mm)	:	36	32	25	30	26	9
Selection Ratio	:	0.43	0.39	0.36	0.37	0.38	0.10
Number in Codend	:						
Selection Cover	:						
Range: Total	:	86	576	418	317	262	17
Total Codend	:						
Number Cover	:						
Caught: Total	:	350	1883	931	677	454	600
Av.Total Codend	:	172	208	324	180	208	136
Catch Cover	:	212	88	76	48	32	72
Weight (kg):Total	:	384	296	400	228	240	208

Species: SOL Gear Type : TBB Sheet nr: 3.

		13	14	15	16	17	18
Author	:	Beek	Beek	Beek	Beek	Beek	Beek
Source	:	1983	1983	1983	1983	1983	1983
ICES Area	:	IVc	IVc	IVc	IVc	IVc	IVc
Test Date	:	8-1981	8-1981	8-1981	8-1981	8-1981	8-1981
Vessel Type	:	C	C	C	C	C	C
Vessel HP	:	1015	1015	1015	1015	1015	1310
Towing Speed (kn)	:	5.25	5.25	5.25	5.25	5.25	5.25
Test Method	:	C	C	C	C	C	C
Nr Hauls	:	13	15	15	15	10	10
Av.duration (min)	:	19	19	22	22	22	93
Mesh Size (mm)	:	69.4	81.1	69.1	81.4	82.5	64.5
Codend Material	:	PA	PA	PA	PA	PA	PA
Single/Double	:	D	D	D	D	D	D
Twine Code	:						
Twine Diam(mm)	:						
Meshes Round+Selv.	:						
Open Meshes	:						
Length Codend(m)	:						
Length Extension(m)	:						
50% length (mm)	:	235	278	226	276	265	225
Selection Factor	:	3.39	3.43	3.27	3.39	3.21	3.49
Selection Range (mm)	:	23	25	24	39	48	36
Selection Ratio	:	0.33	0.31	0.35	0.48	0.58	0.56
Number in Selection Range: Codend	:						
Cover	:						
Total	:	195	234	185	436	330	466
Total Number Caught: Codend	:						
Cover	:						
Total	:	377	451	471	532	401	1346
Av.Total Catch Weight (kg): Codend	:	96	92	144	160	268	
Cover	:	16	16	20	24	28	
Total	:	112	108	164	184	296	236

Species: SOL Gear Type : TBB Sheet nr: 4.

		19	20	21	22	23	24
Author	:	Beek	Beek	Beek	Beek	Beek	Beek
Source	:	1983	1983	1983	1983	1983	1983
ICES Area	:	IVc	IVc	IVc	IVc	IVc	IVc
Test Date	:	8-1981	8-1981	8-1981	8-1981	8-1981	8-1981
Vessel Type	:	C	C	C	C	C	C
Vessel HP	:	1310	1310	1310	1310	1310	1310
Towing Speed (kn)	:	5.25	5.25	5.25	5.25	5.25	5.25
Test Method	:	C	C	C	C	C	C
Nr Hauls	:	14	11	20	7	5	10
Av.duration (min)	:	64	93	63	64	63	122
Mesh Size (mm)	:	64.9	78.9	78.9	92.3	80.3	79.7
Codend Material	:	PA	PA	PA	PA	PA	PA
Single/Double	:	D	D	D	D	D	D
Twine Code	:						
Twine Diam(mm)	:						
Meshes Round+Selv.	:						
Open Meshes	:						
Length Codend(m)	:						
Length Extension(m)	:						
50% length (mm)	:	220	273	269	305	268	274
Selection Factor	:	3.39	3.46	3.41	3.30	3.34	3.44
Selection Range (mm)	:	39	47	39	24	30	35
Selection Ratio	:	0.60	0.60	0.49	0.26	0.37	0.44
Number in Codend	:						
Selection Cover	:						
Range: Total	:	273	836	1532	69	157	939
Total Codend	:						
Number Cover	:						
Caught: Total	:	927	1477	2228	1329	234	2296
Av.Total Codend	:						
Catch Cover	:						
Weight (kg):Total	:	184	164	188	180	116	236

Species: SOL Gear Type : TBB Sheet nr: 5.

		25	26	27	28	29	30
Author	:	Beek	Beek	DeClerc	DeClerc	DeClerc	DeClerc
Source	:	1983	1983	1981	1981	1981	1981
ICES Area	:	IVc	IVc	IVc	IVc	IVc	IVc
Test Date	:	8-1981	8-1981	6-1980	6-1980	6-1980	6-1980
Vessel Type	:	C	C	C	C	C	C
Vessel HP	:	1310	1310	285	285	285	285
Towing Speed (kn)	:	5.25	5.25				
Test Method	:	C	C	C	C	C	C
Nr Hauls	:	5	10	10.1	10.1	10.1	10.1
Av.duration (min)	:	63	122				
Mesh Size (mm)	:	93.8	93.4	78.5	81.8	87.3	90.3
Codend Material	:	PA	PA	PA	PA	PA	PA
Single/Double	:	D	D	S	S	S	S
Twine Code	:			12200Rt	12200Rt	12200Rt	12200Rt
Twine Diam(mm)	:						
Meshes Round+Selv.	:			80	80	80	80
Open Meshes	:			64	64	64	64
Length Codend(m)	:			3.4	3.6	3.8	3.9
Length Extension(m)	:			0	0	0	0
50% length (mm)	:	290	325	245	263	275	281
Selection Factor	:	3.09	3.48	3.12	3.22	3.15	3.11
Selection Range (mm)	:	14	36	31	29	40	36
Selection Ratio	:	0.15	0.39	0.39	0.35	0.46	0.40
Number in Selection Range: Codend	:						
Cover	:						
Total	:	14	225	0	0	0	0
Total Number Caught: Codend	:			1570	1560	987	1150
Cover	:						
Total	:	251	2410	2005	2193	1951	2081
Av.Total Catch Weight (kg): Codend	:						
Cover	:						
Total	:	112	164	0	0	0	0

Species: SOL Gear Type : TBB Sheet nr: 6.

			31	32	33	34	35	36
Author		:	DeClerc	DeClerc	DeClerc	DeClerc	DeClerc	DeClerc
Source		:	1981	1981	1981	1981	1981	1981
ICES Area		:	IV	IV	IV	IV	IV	IV
Test Date		:	11-1980	11-1980	11-1980	11-1980	1-1981	1-1981
Vessel Type		:	C	C	C	C	C	C
Vessel HP		:	420	420	420	420	420	420
Towing Speed (kn)		:						
Test Method		:	C	C	C	C	C	C
Nr Hauls		:	10.1	10.1	10.1	10.1	10.1	10.1
Av.duration (min)		:						
Mesh Size (mm)		:	77.4	81	85.9	90.2	76.9	80.7
Codend Material		:	PA	PA	PA	PA	PA	PA
Single/Double		:	S	S	S	S	S	S
Twine Code		:	12200Rt	12200Rt	12200Rt	12200Rt	12200Rt	12200Rt
Twine Diam(mm)		:						
Meshes Round+Selv.		:	80	80	80	80	80	80
Open Meshes		:	64	64	64	64	64	64
Length Codend(m)		:	3.4	3.6	3.8	3.9	3.4	3.6
Length Extension(m)		:	0	0	0	0	0	0
50% length (mm)		:	252	271	265	304	259	271
Selection Factor		:	3.26	3.35	3.08	3.37	3.37	3.36
Selection Range (mm)		:	34	40	41	50	28	34
Selection Ratio		:	0.44	0.49	0.48	0.55	0.36	0.42
Number in	Codend	:						
Selection	Cover	:						
Range:	Total	:	0	0	0	0	0	0
Total	Codend	:	737	1373	644	785	911	855
Number	Cover	:						
Caught:	Total	:	1144	2789	1232	2588	3873	5249
Av.Total	Codend	:						
Catch	Cover	:						
Weight (kg):	Total	:	0	0	0	0	0	0

Species: SOL Gear Type : TBB Sheet nr: 7.

			37	38	39	40	41	42
Author		:	DeClerc	DeClerc	DeClerc	DeClerc	DeClerc	DeClerc
Source		:	1981	1981	1981	1981	1981	1981
ICES Area		:	IV	IV	IV	IV	IV	IV
Test Date		:	1-1981	1-1981	10-1980	10-1980	10-1980	10-1980
Vessel Type		:	C	C	C	C	C	C
Vessel HP		:	420	420	1320	1320	1320	1320
Towing Speed (kn)		:						
Test Method		:	C	C	C	C	C	C
Nr Hauls		:	10.1	10.1	10.1	10.1	10.1	10.1
Av.duration (min)		:						
Mesh Size (mm)		:	85.6	89.75	75.85	79.3	85	88.6
Codend Material		:	PA	PA	PA	PA	PA	PA
Single/Double		:	S	S	S	S	S	S
Twine Code		:	12200Rt	12200Rt	12200Rt	12200Rt	12200Rt	12200Rt
Twine Diam(mm)		:						
Meshes Round+Selv.		:	80	80	80	80	80	80
Open Meshes		:	64	64	64	64	64	64
Length Codend(m)		:	3.8	3.9	3.4	3.6	3.8	3.9
Length Extension(m)		:	0	0	0	0	0	0
50% length (mm)		:	275	289	242	260	265	278
Selection Factor		:	3.21	3.22	3.19	3.28	3.12	3.14
Selection Range (mm)		:	35	40	37	41	47	49
Selection Ratio		:	0.41	0.45	0.49	0.52	0.55	0.55
Number in	Codend	:						
Selection	Cover	:						
Range:	Total	:	0	0	0	0	0	0
Total	Codend	:	658	644	1609	2061	1356	1793
Number	Cover	:						
Caught:	Total	:	3912	4978	2957	3228	3392	3214
Av.Total	Codend	:						
Catch	Cover	:						
Weight (kg):	Total	:	0	0	0	0	0	0

Species: SOL Gear Type : TBB Sheet nr: 8.

		43	44	45	46	47	48
Author	:	Bohl	Bohl	Bohl	Bohl	Bohl	Bohl
Source	:	1982	1982	1982	1982	1982	1982
ICES Area	:	IVb	IVb	IVb	IVb	IVb	IVb
Test Date	:	6-1981	6-1981	6-1981	6-1981	5-1982	5-1982
Vessel Type	:	C	C	C	C	C	C
Vessel HP	:	250	250	250	250	250	250
Towing Speed (kn)	:	3.5	3.5	3.5	3.5	3.25	3.25
Test Method	:	C	C	C	C	C	C
Nr Hauls	:	38	38	32	32	40	40
Av.duration (min)	:	50	50	52	52	59	59
Mesh Size (mm)	:	69.2	79.3	69.5	90.3	78.9	89.7
Codend Material	:	PA	PA	PA	PA	PA	PA
Single/Double	:	D	D	D	D	D	D
Twine Code	:	210/72	210/72	210/72	210/72	210/72	210/72
Twine Diam(mm)	:						
Meshes Round+Selv.	:						
Open Meshes	:						
Length Codend(m)	:						
Length Extension(m)	:						
50% length (mm)	:	212	242	201	271	237	270
Selection Factor	:	3.06	3.05	2.89	3.00	3.00	3.01
Selection Range (mm)	:	55	40			48	46
Selection Ratio	:	0.79	0.50			0.61	0.51
Number in Codend	:	959	150			887	556
Selection Cover	:	1012	211			1501	721
Range: Total	:	1971	361	0	0	2388	1277
Total Codend	:	1575	1051	1090	334	2507	1864
Number Cover	:	1548	2490	527	1353	3221	4003
Caught: Total	:	3123	3541	1617	1687	5728	5867
Av.Total Codend	:						
Catch Cover	:						
Weight (kg):Total	:	0	0	0	0	0	0

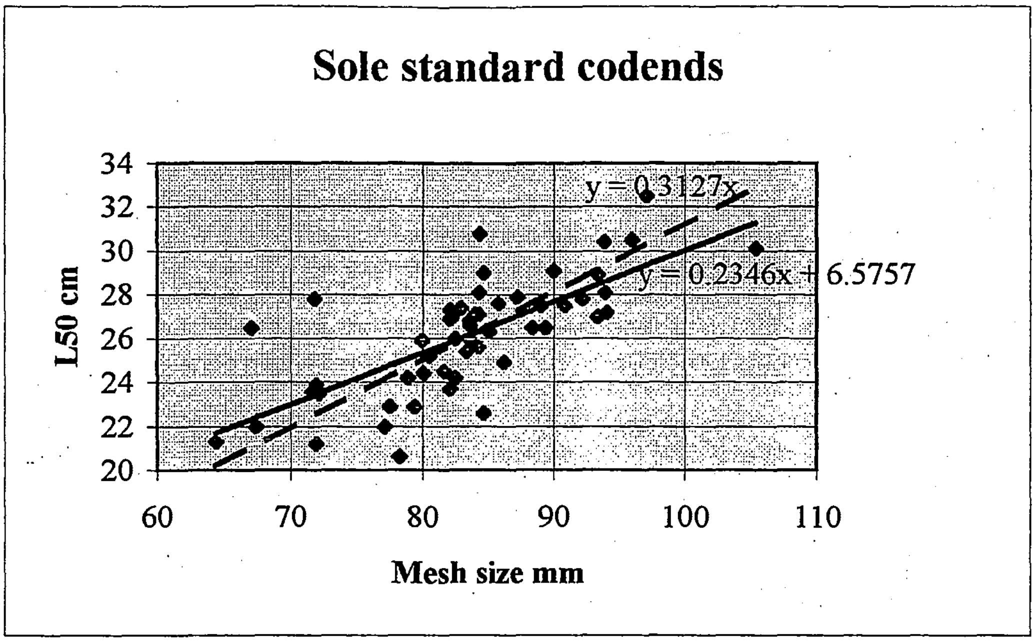
Species: SOL Gear Type : TBB Sheet nr: 9.

			49	50	51	52	53	54
Author		:	Bohl	Bohl	Bohl	Fonteyn	Fonteyn	Fonteyn
Source		:	1982	1982	1982	1988	1988	1992
ICES Area		:	IVb	IVb	IVb	IVc	IVc	IVc
Test Date		:	5-1982	5-1982	5-1982	4-1987	4-1987	4-1988
Vessel Type		:	C	C	C	C	C	C
Vessel HP		:	245	245	245	250	250	250
Towing Speed (kn)		:	3.5	3.5	3.5			
Test Method		:	C	C	C	C	TW	C
Nr Hauls		:	42	31	11	14	15	13
Av.duration (min)		:	52	52	52	60	60	60
Mesh Size (mm)		:	62	77.5	90.4	75.3	74.6	76.4
Codend Material		:	PA	PA	PA	PET	PET	PET
Single/Double		:	D	D	D	D	D	D
Twine Code		:	210/72	210/72	210/72	R4130tx	R4130tx	R4130tx
Twine Diam(mm)		:						
Meshes Round+Selv.		:				100	100	100
Open Meshes		:				84	84	84
Length Codend(m)		:				3	3	6
Length Extension(m)		:				0	0	0
50% length (mm)		:	213	244	272	206	229	229
Selection Factor		:	3.44	3.15	3.01	2.74	3.07	3.00
Selection Range (mm)		:	27	27	45	56	47	53
Selection Ratio		:	0.44	0.35	0.50	0.74	0.63	0.69
Number in	Codend	:	239	128	79			
Selection	Cover	:	287	138	92			
Range:	Total	:	526	266	171	0	0	0
Total	Codend	:	1352	685	204	1306	1153	390
Number	Cover	:	526	978	516	805	2451	110
Caught:	Total	:	1878	1663	720	2111	3604	500
Av.Total	Codend	:						
Catch	Cover	:						
Weight (kg):	Total	:	0	0	0	0	0	0

Species: SOL Gear Type : TBB Sheet nr: 10.

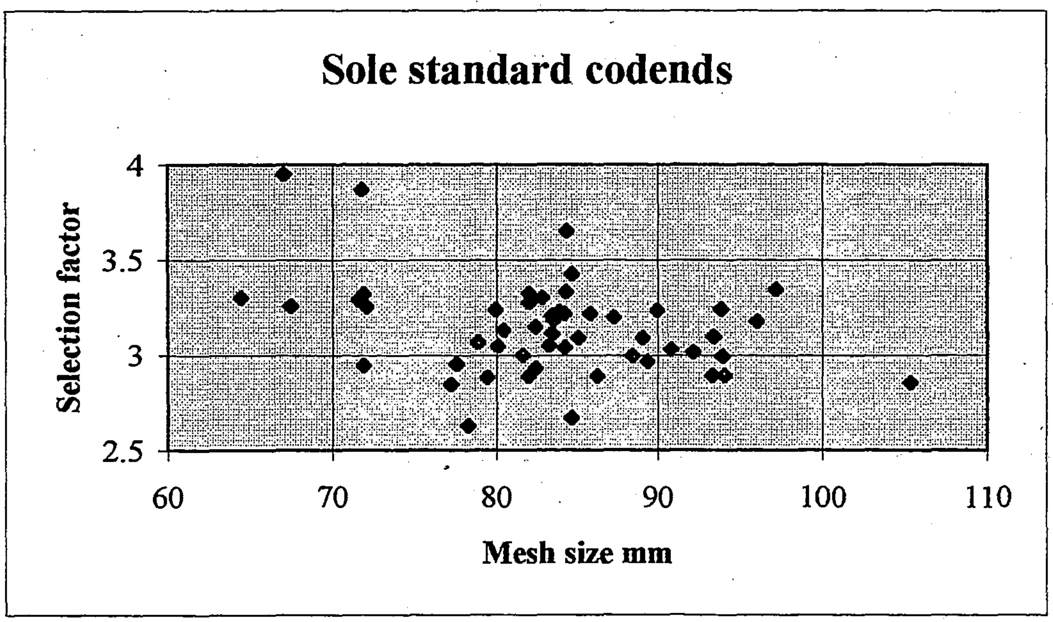
		55	56	57	58	59	60
Author	:	Fonteyn				Fonteyn	Fonteyn
Source	:	1992				1991	1991
ICES Area	:	IVc				IVbc	IVbc
Test Date	:	4-1988				2-1991	3-1991
Vessel Type	:	C				R	R
Vessel HP	:	250				1569	1569
Towing Speed (kn)	:					4	4
Test Method	:	C				C	TW
Nr Hauls	:	13				12	14
Av.duration (min)	:	60				120	120
Mesh Size (mm)	:	74.3				79	80.35
Codend Material	:	PET				PET	PET
Single/Double	:	D				D	D
Twine Code	:	R4130tx				4130Rtx	4130Rtx
Twine Diam(mm)	:						
Meshes Round+Selv.	:	100				100	100
Open Meshes	:	84				84	84
Length Codend(m)	:	3				4.5	4.5
Length Extension(m)	:	0				0	0
50% length (mm)	:	220				270	266
Selection Factor	:	2.96				3.42	3.31
Selection Range (mm)	:	54				108.7	41.3
Selection Ratio	:	0.73				1.38	0.51
Number in Codend	:						
Selection Cover	:						
Range: Total	:	0					
Total Codend	:	410				354	646
Number Cover	:	126				435	1376
Caught: Total	:	536				789	2022
Av.Total Codend	:						
Catch Cover	:						
Weight (kg):Total	:	0					0

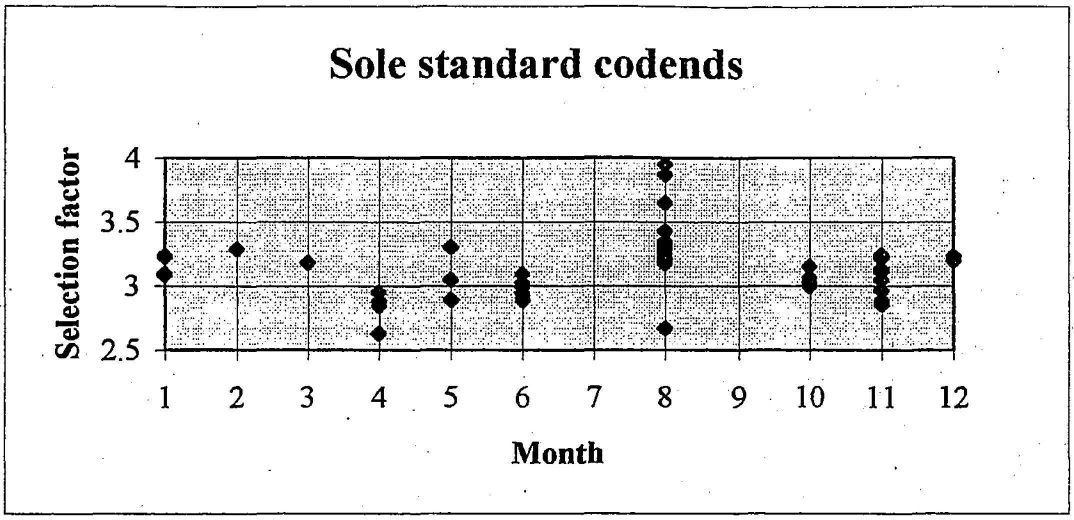
Data Summary	SOL	Codend type		Standard	
Number of data sets	53				
Number of hauls	808				
Number of vessels	10				
		95%Confidence limits		Maximum	Minimum
Mean Selection factor	3.12	3.16	3.07	3.43	2.63
weighted by hauls	3.10				
weighted by sqrt(hauls)	3.11				
Mean Selection range cm	4.0	4.3	3.6	10.9	2.3
weighted by hauls	4.0				
weighted by sqrt(hauls)	4.0				
Mean Selection ratio	0.48	0.52	0.43	1.32	0.25
weighted by hauls	0.49				
weighted by sqrt(hauls)	0.48				

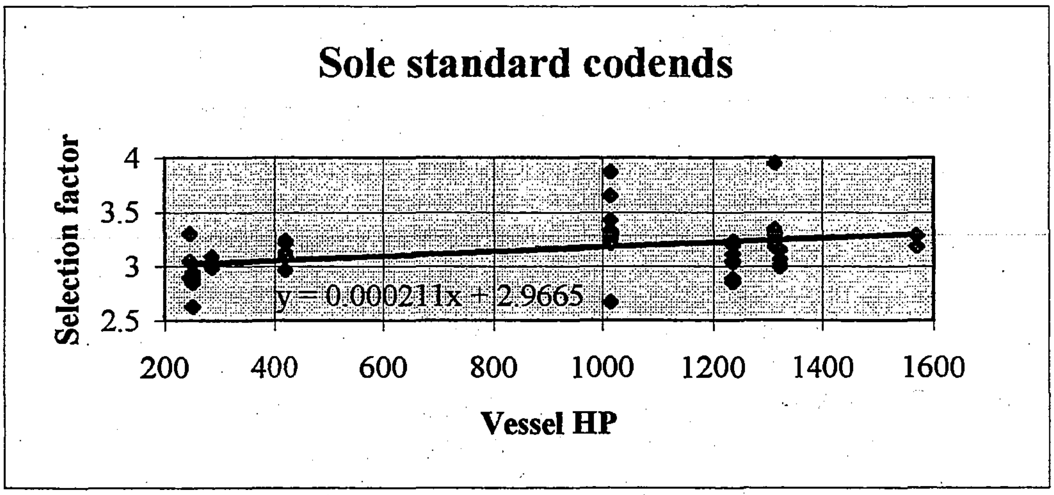


Linear regression	slope	intercept	0.234597	6.575737
L50-mesh size	se slope	se interc	0.031646	2.653409
	r squared	se yest	0.518657	1.837949
	F	df	54.95365	51
	SS regr	SS resid	185.6365	172.2809

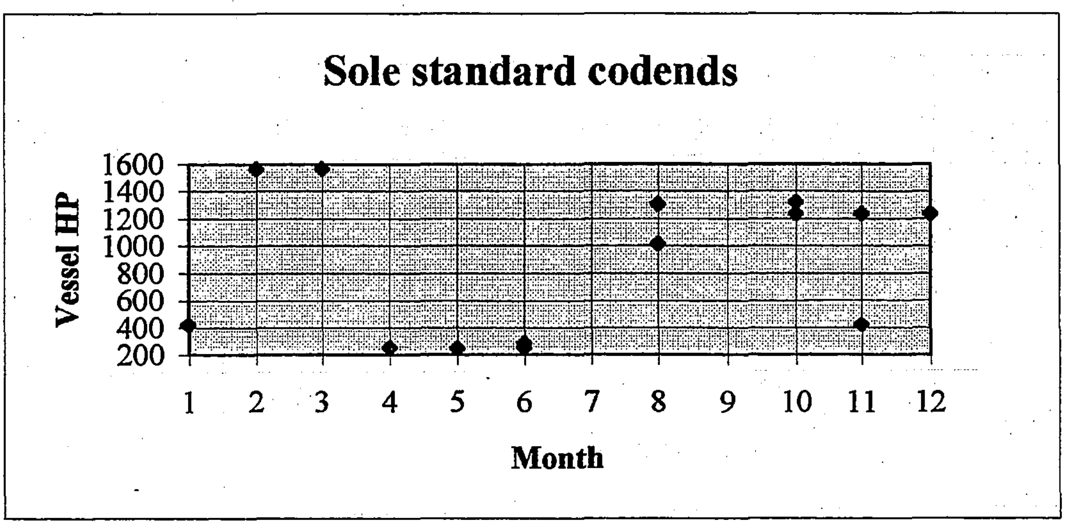
Forced through origin	slope	intercept	0.312668	0
	se slope	se interc	0.003156	#N/A
	r squared	se yest	0.460693	1.926673
	F	df	44.41997	52
	SS regr	SS resid	164.8899	193.0275

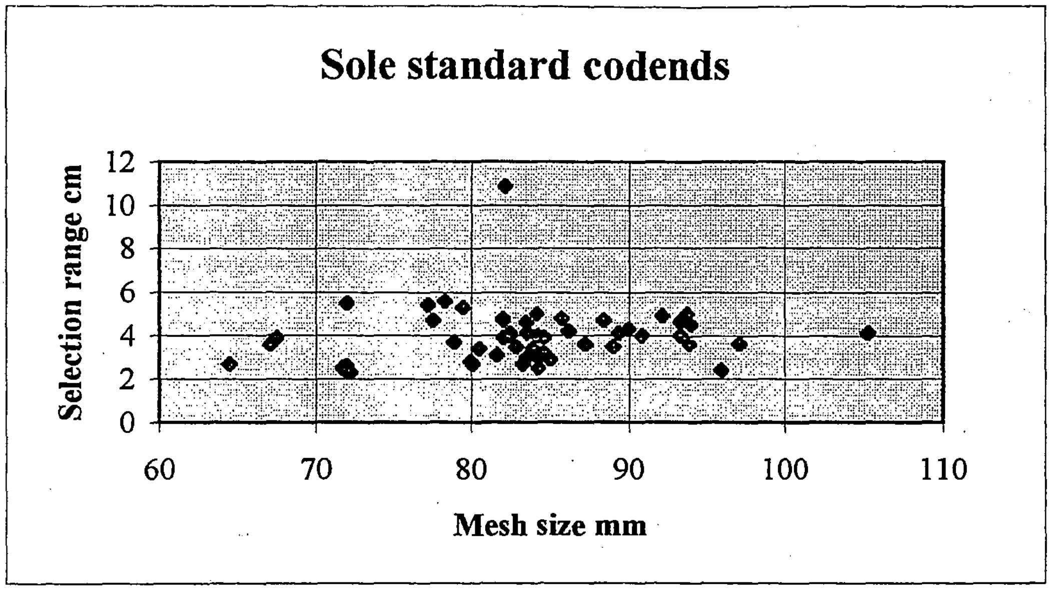




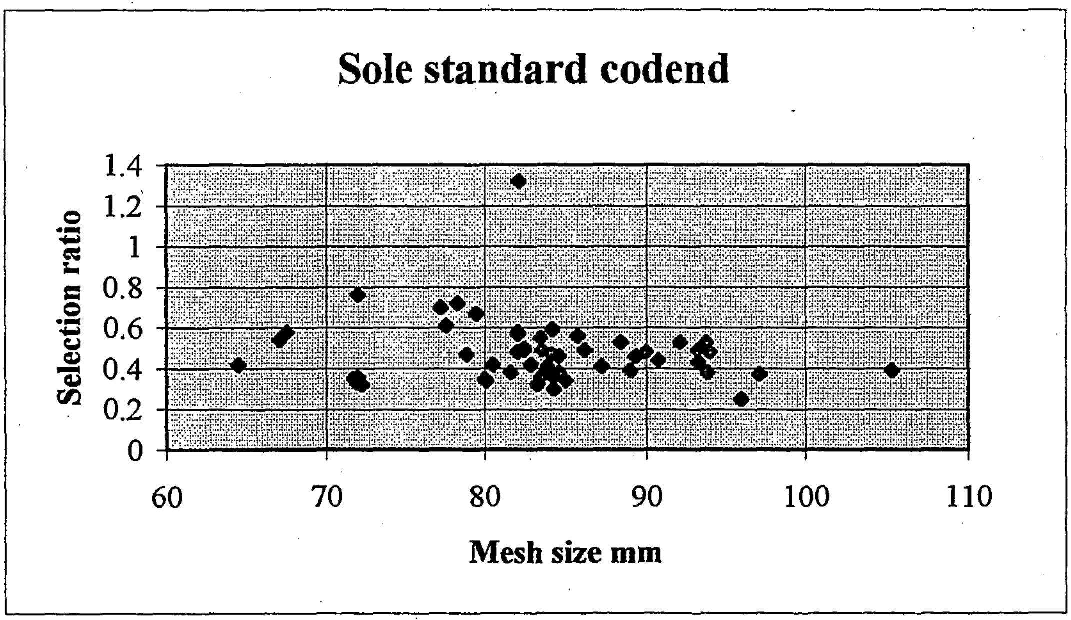


Linear regression	slope	intercept	0.000211	2.966499
Selection factor - Vessel HP	se slope	se interc	6.63E-05	0.063074
	r squared	se yest	0.166307	0.225791
	F	df	10.17362	51
	SS regr	SS resid	0.518666	2.600053





Linear regression	slope	intercept	0.019321	2.35528
Selection range-mesh size	se slope	se interc	0.022704	1.903594
	r squared	se yest	0.014002	1.318571
	F	df	0.724233	51
	SS regr	SS resid	1.259173	88.6701



Appendix 4

Gill net selectivity measurements

Cod North Sea
Sole North Sea + English Channel
Plaice North Sea

Overview of the Gill Net Selectivity Experiments carried out

Species	Nation	Gear	Period	ICES Area	Months	Year	Total Days	Number caught	Significant bycatches cod	plaice	sole	Girth Width	Method capture
Cod	DK	Multimono Gill net	1	IVb	10-11	1994	12	2608		308	103	yes	
			2	IVb	2-3	1995	4	1101		209	1		
			3	IVb	4	1995	7	3230		863	440	yes	
			4	IVb	11-12	1995	11	1010		93	7		yes
Cod	ENG	Multifil Trammel	1	IVb	11	1994	5	111				yes	
			2	IVb	1	1995	6	495					
			3	IVb	3	1995	5	248					
			4	IVb	11-12	1995	7	774					
			5	IVb	2	1996	7	1021					
			6	IVb	3	1996	2	155					
			7	IVb	3	1996	4	420					
Sole	DK	Multimono Gill net	1	IVb	5-6	1995	24	10547	788	3405		yes	yes
Sole	ENG	Multimono Trammel	1	VIId	2	1995	6	321					
			2	VIId	3	1995	7	787					
			3	VIId	9	1995	6	660				yes	
			4	VIId	2	1996	6	177					
Sole	FR	Multifil Trammel	1	IVc	3-4	1995	10	2202				yes	
			2	VIId	6	1995	4	385				yes	
			3	VIId	11-12	1995	6	313				yes	
			4	IVc	2-4	1996	10	1869				yes	
Sole	FR	Multimono Trammel	1	IVc	3-4	1995	10	1359				yes	
			2	VIId	6	1995	4	297				yes	
			3	VIId	11-12	1995	6	179				yes	
			4	IVc	2-4	1996	10	1300				yes	
Plaice	DK	Multimono Trammel	1	IVb	8	1994	11	1741	471		31	yes	
			2	IVb	10	1994	6	3270	237		34		
			3	IVb	4-6	1995	12	12151	780		1636	yes	

Principal Details of Trials Vessels

Species	Nation	Registration Number	Name	Home Port	Type	Length m	HP	Usual trip days	Max length nets used km
Cod Sole Plaice	Denmark	L376	Helle	Thorsminde	Wooden gill netter	10.09	96	1	3.6 km Cod 4.2 km Plaice 5.3 km Sole
Cod	England	WY164	Roseanne	Whitby	Wooden gill netter	9.98	180	1	4.2
Hake	England	PZ498	Boy Anthony	Newlyn	Wooden gill netter	18.3	287	8	12.8
Hake	France	LO766836	Amour de la Mer	Lorient	Trawler/gill netter	17.5	350	10	10
Sole	England	RX60	St. Richard	Hastings	Wooden gill netter	9.8	70	1	3.2
Sole	France	BL734532	La tendresse	Boulogne sur mer	GRP gill netter	16.5	220	1	10

Principal dimensions of the experimental nets

Species	Nation	Net type	Material	Net height	Hanging upper	Ratio lower	Mesh size (measured) mm						
Cod	DK	Gill	Multimono*	3.80m	0.38	0.50	90	99	108	123	134	151	
Cod	ENG	Trammel	Multifil	2.34m	0.51	0.51	103	116	128	136			
Hake	ENG	Gill	Monofil*	5.8m	0.56	0.56	92	106	116	129	143		
Hake	FR	Gill	Monofil	8.0m	0.50	0.50	80	89	99	110	122		
Sole	DK	Gill	Multimono	1.22m	0.27	0.33	81	86	92	99	105	113	118
Sole	ENG	Trammel	Multimono	1.95m	0.51	0.51	97	102	110	123	128		
Sole	FR	Trammel	Multimono	1.55m	0.40	0.43	84	90	96	100	110		
Sole	FR	Trammel	Multifil	1.55m	0.40	0.43	84	90	96	100	110		
Plaice	DK	Trammel	Multimono	1.27m	0.38	0.45	98	108	119	129	140	151	

* Twine size increases with mesh size

Principal operational details for the experimental nets

Species	Nation	Period	Valid sets	Fleets per set	Nets per fleet	Total length per set km	Soak time hours	Water depth m
Cod	DK	1	12	5-10	6	2.1-4.2	22 (5-28)	17-26
		2	4	5-8	6	2.1-3.3	22 (20-25)	7-20
		3	7	4-7	6	1.7-2.9	23 (7-27)	15-19
		4	11	4-7	6	1.7-2.9	22 (17-26)	14-28
Cod	ENG	1	5	4-5	4	1.5-1.9	7-10	49-55
		2	4	4	4	1.5	7-10	33-42
		3	5	4	4	1.5	7-10	47-51
		4	6	7	4	2.6	7-10	30-42
		5	6	7	4	2.6	7-10	30-42
		6	2	7	4	2.6	7-10	36-48
		7	4	7	4	2.6	7-10	36-48
Sole	DK	1	24	6-9	7	2.2-3.3	12 (10-14)	9-24
Sole	ENG	1	6	6-8	5	1.5-2.0	18-20	33-42
		2	7	6-8	5	1.5-2.0	18-20	33-42
		3	6	6-8	5	1.5-2.0	18-20	33-42
		4	6	6-8	5	1.5-2.0	18-20	33-42
Sole	FR	1	10	2*	20	1.6	20	8-20
		2	4	2*	20	1.6	20	15-30
		3	6	2*	20	1.6	20	15-30
		4	10	2*	20	1.6	20	8-20
Plaice	DK	1	10	9-13	6	2.5-3.7	7 (4-26)	19-34
		2	6	2-7	6	0.6-2.0	5 or 19	15-35
		3	12	4-8	6	1.1-2.3	24 (7-27)	10-18

* 1 fleet Multimono + 1 fleet Multifilament

GILL NET SELECTIVITY DATA COD

Nation	DEN	DEN	DEN	ENG
Gear	G	G	T	T
Target species	COD	SOL	PLE	COD
Twine	Mmono	Mmono	Mmono	Mfil
No. mesh sizes	6	7	6	4
Range mm	90-151	81-118	98-151	103-136
Selectivity parameters				
k	4.331	4.624	4.462	4.548
st	0.282	0.259	0.211	0.354
C1	0.065	0.104	0.112	0.082
C2	0.210	0.358	0.508	0.551
Catch numbers				
Total no.	7949	788	1488	3224
No.<<k	1685	218	1058	577
No.>>k	1002	87	70	429
Remainder	5262	482	360	2218

WEIGHTED MEANS		
G	T	G+T
4.356	4.536	4.411
0.280	0.334	0.297
0.069	0.101	0.084
0.222	0.545	

GILL NET SELECTIVITY DATA SOL

Nation	DEN	DEN	DEN	ENG	FR			
Gear	G	G	T	T	T			
Target species	SOL	COD	PLE	SOL	SOL			
Twine	Mmono	Mmono	Mmono	Mmono	Mfil			
No. mesh sizes	7	6	6	5	5			
Range mm	81-118	90-151	98-151	97-128	84-111	WEIGHTED MEANS		
Selectivity parameters						G	T	G+T
k	3.291	3.034	3.181	3.112	3.263	3.278	3.209	3.249
st	0.246	0.248	0.298	0.333	0.226	0.246	0.267	0.255
C1	0.044	0.023	0.035	0.006	0.013	0.043	0.021	0.035
C2	0.231	0.067	0.010	0.004	0.523	0.219	0.508	
Catch numbers								
Total no.	10547	551	1701	1945	4769			
No.<<k	1603	67	447	193	415			
No.>>k	232	18	5	14	634			
Remainder	8712	466	1249	1739	3720			

GILL NET SELECTIVITY DATA PLE

Nation	DEN	DEN	DEN
Gear	T	G	G
Target species	PLE	SOL	COD
Twine	Mmono	Mmono	Mmono
No. mesh sizes	6	7	6
Range mm	98-151	81-118	90-151
Selectivity parameters			
k	2.513	2.636	2.532
st	0.314	0.355	0.369
C1	0.000	0.000	0.000
C2	0.138	0.141	0.227
Catch numbers			
Total no.	17162	3405	1473
No.<<k	429	31	24
No.>>k	481	235	105
Remainder	16252	3139	1345

WEIGHTED MEANS		
T	G	G+T
2.513	2.605	2.533
0.314	0.359	0.324
0.000	0.000	0.000
0.138	0.167	0.150

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