RELATIVE SIZE AND GIRTH SELECTIVITY OF COD GILLNETS IN THE WESTERN BALTIC

BY

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Abstract

During 3 years a lot of cod catch data were collected from different gill- and trammel nets during commercial fisheries. For a rough estimation of the relative selectivity the retention curves from this experiments were fitted by one or two Gauss normal distributions by the method of least squares. The results show, that there is no relevant difference in relative selectivity between gill- and trammel nets, but only in the efficiency. Because of the small differences in relative selectivity the catching process were investigated during the reported experiments in detail. Five catching modes were defined and the retained cod for each mode were recorded separately. The five modes are: cod enmeshed behind the gills, enmeshed at the head, hooked at the maxillaries or one gill cover and then entangled, caught by a mesh bar in the mouth and additionally enmeshed and caught by a mesh bar and additionally entangled in a pocket of gillnet meshes. The typical selectivity curve of a gillnet is not symmetric. The analysis of the data shows that the retention curve of each catch mode can be fitted by a normal density function. Gillnet selectivity is determined primarily by the girth. Therefore all caught cod are measured by length and girth. The girth selectivity is not significant dependent from the seasons. The girth length relation was found to be changed by seasons and by different year classes corresponding to different relative size selectivity.

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Introduction

The fishery on Baltic cod with set nets in Germany was intensified in the early 80s when during the oil crisis energy saving fishing gear became more important. In addition the introduction of multi-monofilament netting material increased the catches considerably. Many fishermen changed from trawls to set nets which could be used on rough fishing grounds. The same development could be observed during the last ten years in the eastern Baltic states (Zaucha et al. 1993, Baranova, T. and Shics 1995).

The EU Commission held a first meeting of experts discussing the problems for regulating the fixed gears in 1993 (Pawson et al. 1993). To protect the fish stocks mesh size and fishing effort regulations became necessary corresponding to regulations by technical measures. The results of the EU study "BIOECO 93/16" are reported which give information on to the dependence of the relative selectivity on mesh sizes. In addition to the results of that study data collected 1983 ‐ 85 by the Institute of gear technology , Hamburg,(IFH) are evaluated.

Material and methods:

The selectivity is defined as the proportion of fish captured and retained from either those in the population, or the ones encounter the nets. Because selectivity is usually described as a relative rather than an absolute value, both definitions are equal, if the

encounter does not vary with fish size. Because there is no practical way of estimating the probability of catching a fish that encountered a gillnet the usual definition of gillnet selectivity is given by Hamley (1975): The size selectivity of a gear may be defined by a curve giving for each size of fish the proportion of the total population of that size which is caught and retained by a unit operation of the gear. Thus, size selectivity is the proportionality constant sl_{ij} in

$$C_{ij} = sl_{ij} \cdot X_i \cdot N \qquad (1)$$

And for girth selectivity:

$$C_{ij} = sg_{ii} \cdot X_i \cdot N_j \qquad (1a)$$

The shape of the selectivity curves are described by different functions (Hamley 1975; Holst, R. and Moth-Poulsen, T. 1995a+b). Symmetrical selectivity curves are usually represented by the normal density function (Holt 1963). Slightly skewed selectivity curves have been fitted to a "skew normal" distribution, a truncated Gram-Charlier series (Regier and Robson 1966; Helser et al. 1990, 1994). More generalised curves have been fitted by a composite of two normal distribution functions (Sechin 1969) and by a Pearson's type I curve (Hamley and Regier 1973). When fish are caught in nets by several ways, selectivity curves may be multimodal or otherwise complex. (Hamley and Regier 1973; Wileman 1997).

The **indirect** method for measuring gillnet selectivity is most popular and used exclusively in marine fisheries but only gives a relative measure of selectivity (Hamley and Regier 1973). The assumption usually is that each mesh size has equal catching efficiency for the length class of fish with the highest retention probability in that mesh size. This optimal length class is referred to as the modal length and the selectivity of other length classes are measured relative to the selectivity of the modal length

The size distribution of the catches gives a rough estimation of the selectivity. This **catch based model** for selectivity estimation cannot be used for stock assessments. However, for the estimation of the minimum mesh size for regulation purposes this method is precise enough.

For more detailed and more precise estimation of the selectivity by the catch based model the catch was analysed by the five different ways cod are caught in gillnets The retention curve of each catch mode can be fitted by a normal density function especially the curve of gilled cod. The selectivity curve can be estimated by the sum of the five fitted curves. By this method the selectivity ranges of the different curves is less than the range of the selectivity curve fitted by one function over all.

The influence of the length distribution of the stock decreases when the selectivity range decreases . Figure 3 shows the result of the influence of decreasing number of cod entered the gillnets. The curve of the gilled cod of a net of 110 mm mesh size was fitted by a Gauss curve. Afterwards a decreasing of the length distribution in the range in 10 cm by 10 to 70% was taken into account. A refitting of these curves results a shift of less than 1 cm to higher values. .

During the trials of this project the cod were careful removed from the nets and the first catch mode and additional catch modes if existent were estimated. The catch modes from own experience and experimental results of different gill net constructions should be divided in five main classes, each with a different escape way as shown in figure 1. The signs of abbreviation for the catch modes are given in brackets using following figures:

a) Cod "enmeshed behind the gills" (g)

b) Cod "enmeshed at the head" (h)

c) Cod "hooked at the maxillaries" or one gill cover and then entangled (mx)

d) Cod caught "by a mesh bar and entangled in a net pocket" (ml)

e) Cod caught "by a mesh bar and enmeshed" (m2)

Because the selectivity of gill nets responds directly to the circumference of fish, the selectivity by length and girth are estimated. For the purpose of measuring the girth a measuring system was developed

All cod are measured by length and girth. The length is measured on a measuring board with a solution of 1 cm and measured by the method of cm below. The girth was measured with a twine at maximum body girth with the method of cm below.

At the IFH a girth measurement system was developed that allows measuring girth as easy as length with constant tension of 1 Newton (Figure 3 A). A movable desk was added to a length measuring board. At one end a double loop with different diameter is fixed to the moveable desk and at the other end the outer loop to the frame of the system and the inner loop to a force sensor. For measuring girth the desk is moved to the left side and both loops are opened. The fish must be pushed through the inner loop until maximum girth. Then the desk has to be moved to the right. During the movement the double loops are closing as shown in principle in figure 3 B. If the inner loop surrounds the fish and a tension of 1 Newton occurs to the loop, the desk is stopped by a stop magnet and the girth may be read out by a mark on the desk and a scale with decreasing values to the right on the measuring board.

During every period of this project several thousand of cod where measured by length and girth. For the length-girth-relation all length values for every girth class were fitted by a normal distribution by the method of least squares. The modal length were plotted in a graph.

Results

The selectivity curves for the catch mode "caught by a mesh bar and entangled in a net pocket" (ml) were estimated by fitting the data from November 1997 by a normal distribution. In other periods the collected data were not sufficient for analysis. The modal length was nearly independent from mesh size. Only the peak values decreased with increasing mesh size (see figure 4). It must be noted, that nets with 1000 meshes are compared in this study. Net lengths depending on the mesh size were 50 – 80 meter. It can be concluded from a nearly constant modal length that the shape of the retention curves shows the length frequency distribution of cod encountered the net where length classes correspond to one year class. The absolute value of selectivity for this mode must be very low because normally only a few cod of these length classes are caught by this catch method. For estimating the absolute selectivity or for estimating relative selectivity of other catch modes the knowledge of the length frequency distribution of the cod population is required.

Figures 6, 8 and IO show the results of the investigation on the influence of the mesh size on the relative size selectivity of cod gill nets from Feb 97, Nov 97 and Feb 98.

The selectivity curves of the drfferent way of catching are estimated by fitting the retention curves by one normal distribution. A pair of selectivity curves are estimated for each mesh size. The selectivity for the catch mode enmeshed behind the gills (g) relative to the modal length and the sum of all catch modes except ml relative to the length most vulnerable to the nets. The corresponding results for girth are shown in figure 5, 7 and 9.

The steeply increasing slope of the retention curve of the main catch mode corresponds well with the increasing slope of the sum of all catch modes. Only a difference could be found between the modal length of this catch mode and the length most susceptible to the nets. The results have shown, that only the calculation of the catch mode "enmeshed behind the gills" is required for estimating L_{50}.

The L_{50} values calculated from the modal length and the standard deviation are shown in figure 11. They give two nearly identical linear functions for the two pre spawning seasons and a parallel function shifted to higher values of about 1.5 cm for the feeding stock. This difference results from the different shape of cod of the two stocks. The analysis of the girth data gave no difference between the two seasons.

From the data of figure 11 the L_{50} values related to the mesh size 2a results for the autumn seasons (feeding stock) in:

$$L_{50} = (2a \quad 100) \cdot 4,6 + 405 \, [mm] \qquad (2)$$

and for the spring season (pre spawning stock) in

$$L_{50} = (2a \quad 100) \cdot 4,5 + 430 \, [mm] \qquad (3)$$

1983 to 1985 the length distribution of the caught cod of 10 different gillnets with mesh sizes from 90 mm to 140 mm and 12 different trammel nets were collected. Only the data of the retention curves where available for analysis. The fitting by one normal distribution could be well done if the retention curves seemed to be symmetric. The approximation by two curves gives a better fitting at greater length classes if the curves are skew to the greater length classes (mesh sizes up to 120 mm). The influence on the ascending part of the selectivity curve is of no importance.

The L_{50} value of the selectivity curves estimated by the modal length minus 1.18 $_x$ standard deviation of both gill nets and trammel nets corresponds nearly linear to the mesh size. This difference between both net types can be neglected (see figure 13), but not between the absolute selectivity as the efficiency of the trammel nets is different. The efficiency of trammel nets for cod is about 1.5 to 2 times greater than the efficiency of the gill nets. From the data of figure 13 a linear regression of the L_{50} values related to the mesh size 2a results in:

$$L_{50} = (2a \quad 100) \cdot 3,7 + 410 \, [mm] \qquad (4)$$

During selectivity experiments usually a sub-sample of about 200 cod is measured by length and girth. The length girth relation is estimated by a linear regression. During the tests of this project most cod were measured by length and girth, more than 3000 cod for every investigation period. The lengths of every girth class were fitted by a normal distribution. The values of the modal lengths are plotted in the figure 14. In Feb 98 the girth measurement system failed. A systematic reading error of about + 2 cm was estimated by analysis of girth selectivity. Except the investigation period of November 1997 the values of the modal length follows a linear function. In November 1997 the modal length follows two linear functions with a step at a girth of about 20 cm. The step caused a deviation of the modal girth or modal length at mesh size 100 mm or 110 mm as shown in figure 7 and 8. Standard deviation is more than double caused in this case.

4.   Discussion

The analysis of the retention curves from former investigations and simple modelling of the selectivity using Gauss normal distribution for regression results in relative selectivity curves which are sufficient for laying down the mesh size needed for technical measures. The possible errors are equal or less than those caused by mesh size, length or girth measurement. The estimated value of L_{50} of the minimum mesh size for cod fishery in the Baltic is obviously greater than the minimum landing size.

The detailed investigation of the primary and additionally catch modes showed that the relative selectivity can be influenced by the behaviour and shape of the cod. In this report only the main catch mode "enmeshed behind the gills" is considered for

calculation of the L_{50} values. These values are calculated from the modal length and standard deviation of the regression of the retention curves by a normal distribution. The retention curves are influenced by the length frequency distribution of the cod stock and therefore the program for calculating the regression should be extended by an algorithm considering this fact.

Corresponding to the actual minimum landing size (MLZ) of 35 cm, the minimum mesh size (2a) is 83 mm for gill and trammel nets. Both investigation periods give the same result. For feeding stocks the minimum mesh size should be increased by about 5 mm.

5. References

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Zaucha, J.; Blady, W.; Czajka, W.:Preliminary studies of selectivity of cod gill nets in the Baltic. ICES C.M. 1993/B:12.
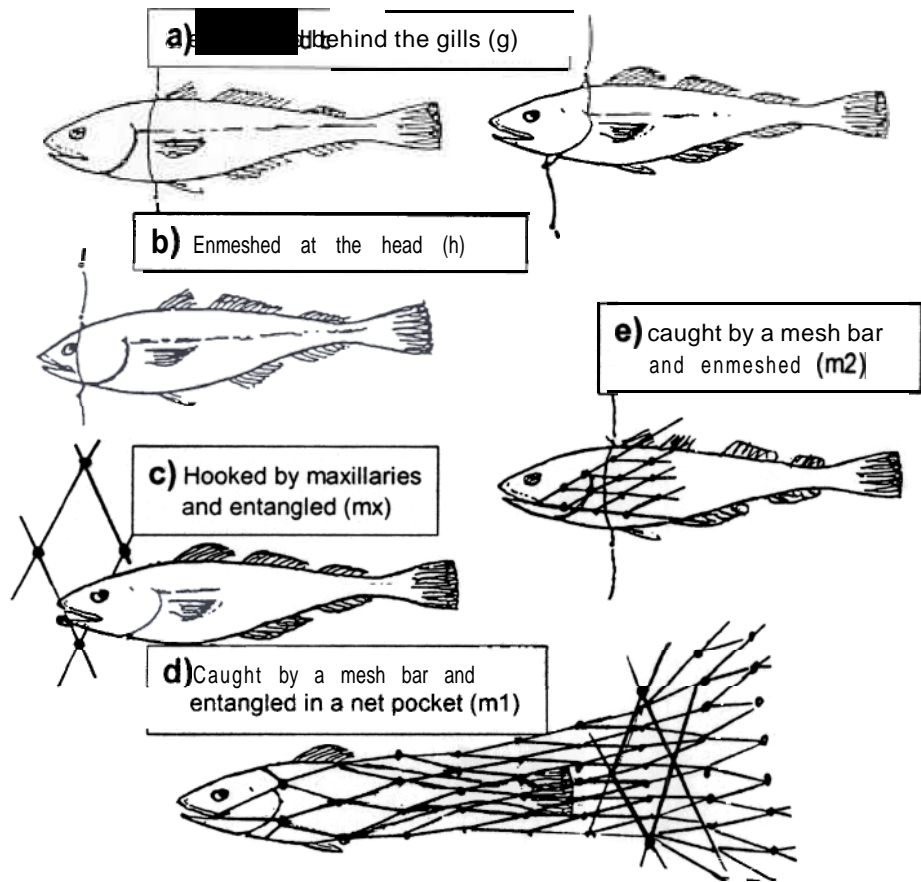
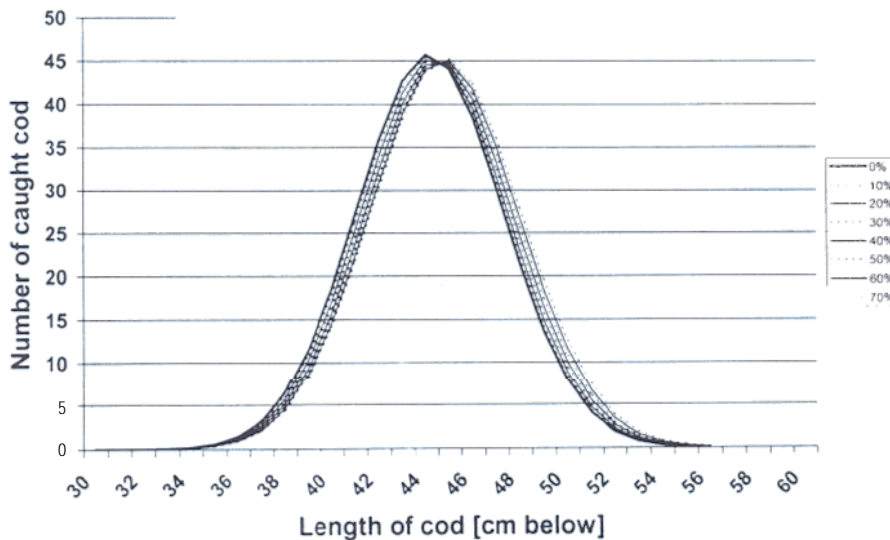**Figure 1:** Five different catch modes of cod in gillnets

Figure 2 : Influence of length frequency distribution on symmetrical retention curves; linear reduction of length distribution of 0-70% in the range +/- 5 cm of modal length

Example of gillnet 110 mm mesh size; catch mode: „behind the gills" (g) standard deviation 3,11cm ; modal length 44,66 cm
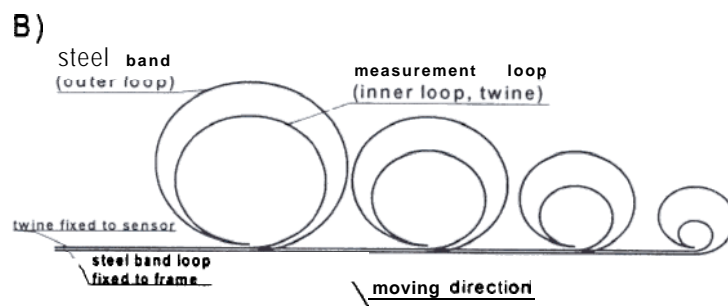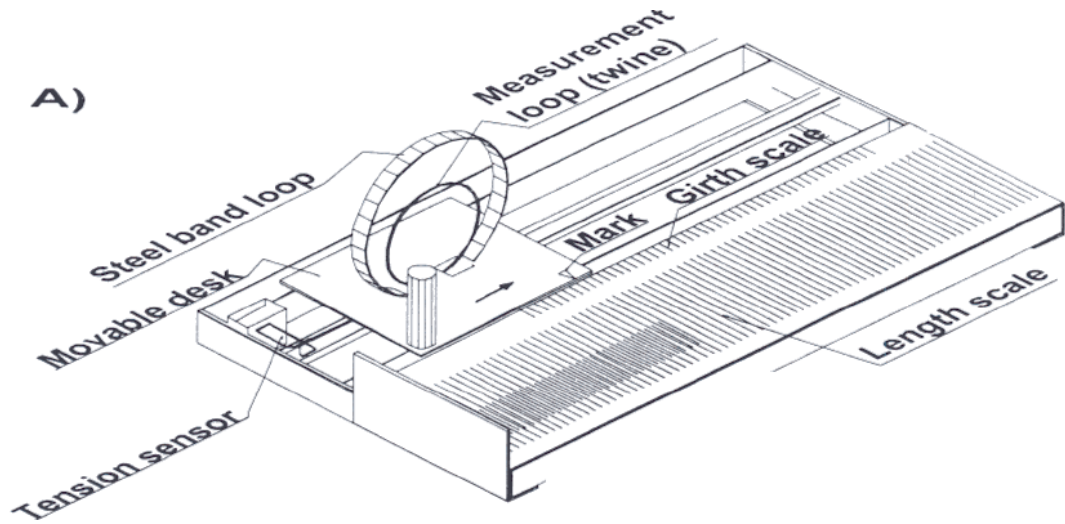
A)

B)
steel **band** (outer loop)
measurement **loop** (inner loop, twine)
twine fixed to sensor
steel band loop fixed to frame
moving direction

Figure 3:   A)General arrangement of girth/Length measurement system

B) Principle of closing the double loop during the moving of the

desk to the right hand
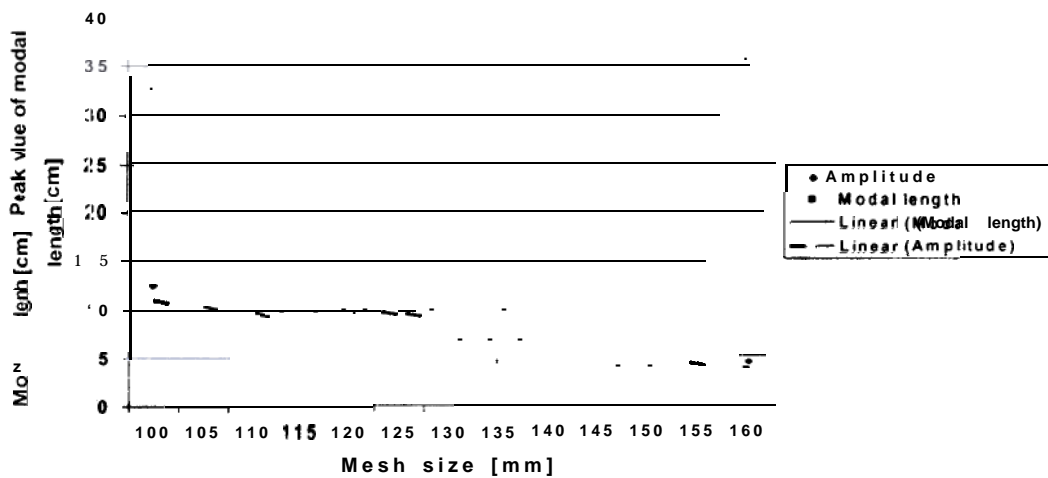
Figure 4:   Modal length and peak value of the retention curves fitted by a normal
distribution of the catch mode "caught by a mesh bar and entangled'
(m1)
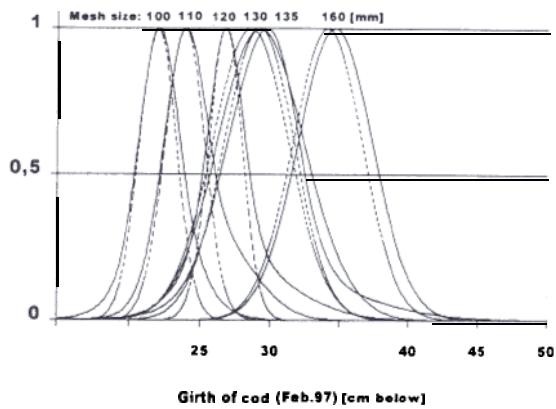
Figure 5: Relative girth selectivity Feb. 97
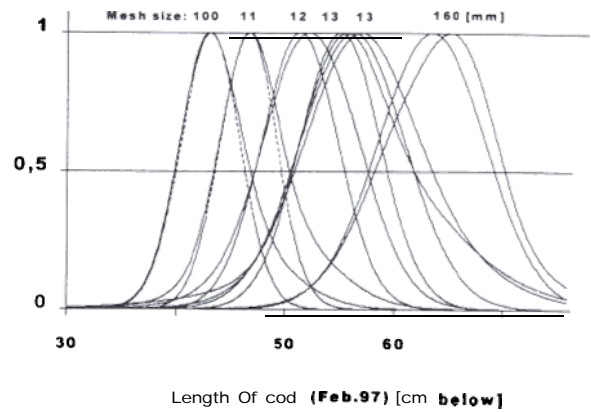
Figure 6: Relative length selectivity Feb 97
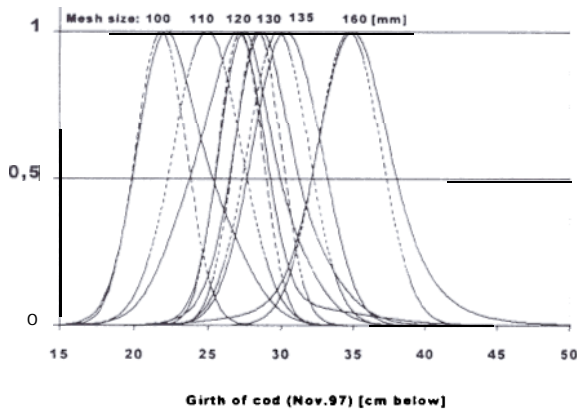
Figure 7: Relative girth selectivity Nov. 97
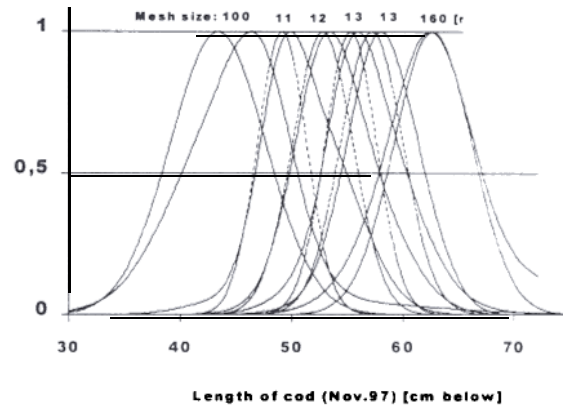
Figure 8: Relative length selectivity Nov.97
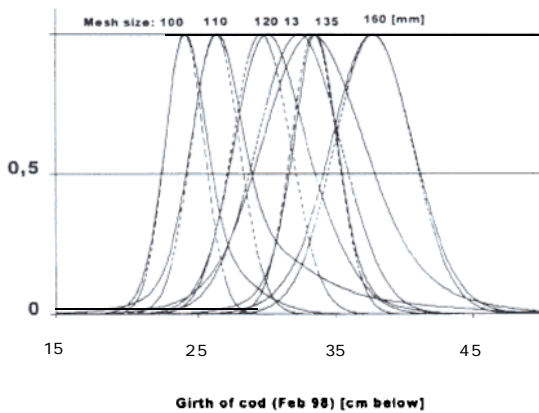
Figure 9: Relative girth selectivity Feb. 98
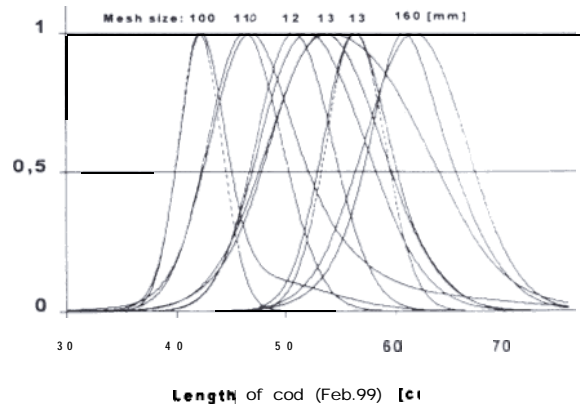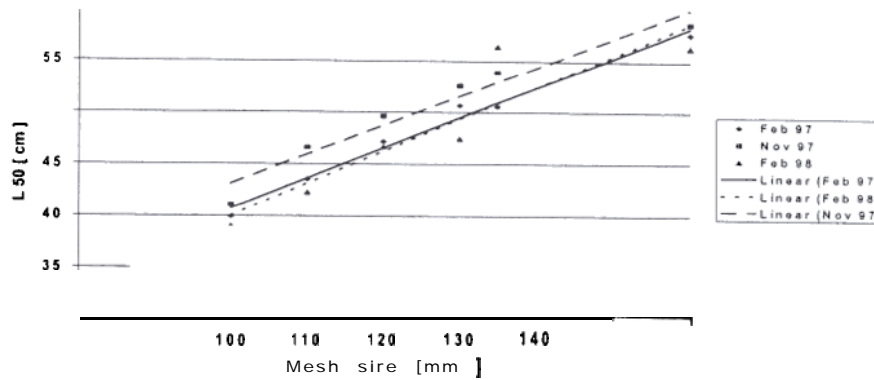

Figure 10: Relative length selectivity Feb.98

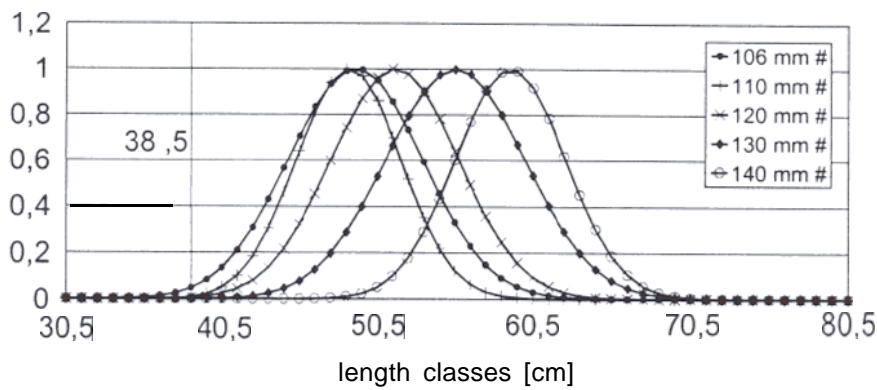**Figure 11:** $L_{50} = L_m - 1.18 \ast SD$ of the main catch mode "enmeshed behind the gills"

Figure 12: Averaged retention curves of gillnets approximated by **one** Gauss normal distribution, Investigation period 1983-l 985
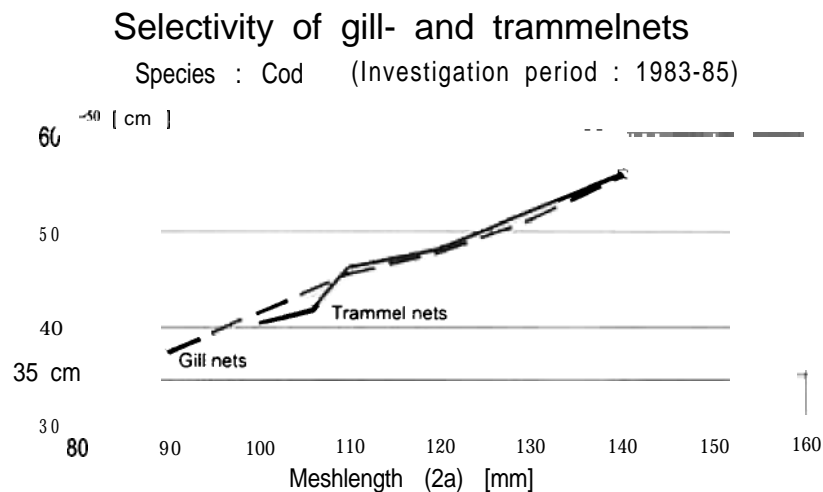

Selectivity of gill- and trammelnets

Species : Cod   (Investigation period : 1983-85)

Figure 13: L_{50} = modal length $- 1.18$ x standard deviation. Mean values of L_{50} estimated by fitting of the retention curves. Data collected 1983 - 85
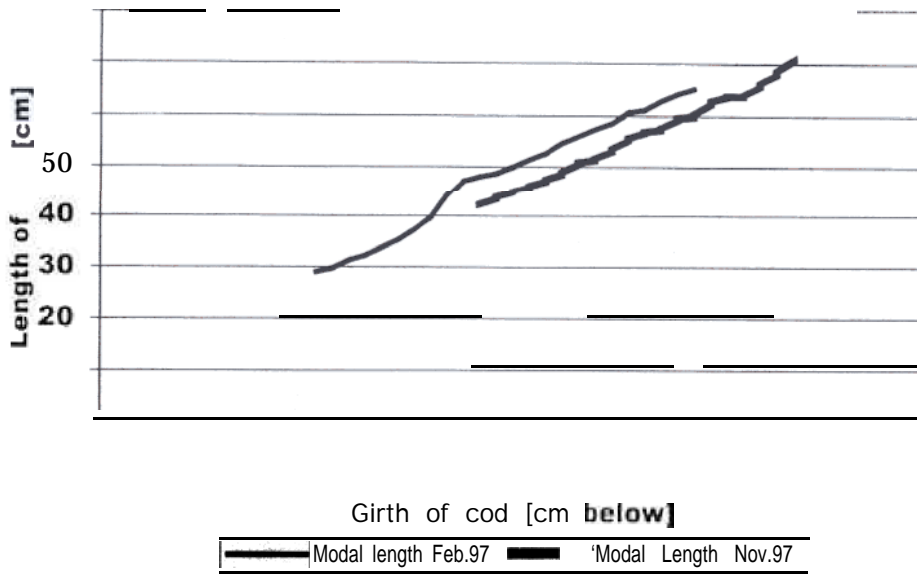
Girth of cod [cm below]

—— Modal length Feb.97 ■■■■ 'Modal Length Nov.97

Figure 14· ength girth relation cod