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# Results of the Canadian 145 mm Diamond Codend Mesh Selection Experiments for Greenland Halibut in the NAFO Area

by

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## Abstract

Mesh selection experiments for Greenland halibut were carried out aboard a Canadian deepsea trawler to determine the selectivity parameters of 145-mm diamond mesh codend. A common bottom trawl used for fishing Greenland halibut was redesign as a trouser trawl with a 50-mm control mesh. Fourteen successful hauls of approximately 4-hour duration were made under commercial fishing conditions in depths ranging from 978 to 1283 m. Selection lengths at L25% was estimated to be 44.04 cm, at L50% 47.74 cm and at L75% 51.45 cm with a selection range (SR) of 7.41 and a selection factor (SF) of 3.29.

## Introduction

The Canadian offshore groundfish fleet is required to use a minimum mesh size of 145 mm (exception is redfish where the minimum is 90 mm) in the codend of their otter trawls. This regulation has been in use since the early-1990s. Canadian fishers involved in the Greenland halibut offshore trawl fishery (NAFO Subdivisions 0, 2, and 3) also have a regulated minimum landing size for Greenland halibut of 45 cm since the mid-1990s. Canadian fisheries management have adopted higher minimum mesh sizes and minimum landing sizes for gadoids and flatfish than NAFO's current regulations in an attempt to reduce the catches of juveniles. These regulations were adopted during a time of poor recruitment, over-exploitation and closure of many groundfis h stocks off the east coast of Canada in the early 1990s.

Selectivity measurements for all fishing gears in a fishery are necessary especially during the rebuilding phase. Information on the shape and slope (selection range) of the selection curve and 50% retention lengths is required by both assessment biologists and fishery managers to assess the effect of a change in mesh size. Close cooperation between industry and the Department of Fisheries and Oceans Canada led to the design of experiments to measure the selectivity parameters of 145 mm diamond mesh codends used in the Canadian Greenland halibut fishery. This paper will report on the results of these experiments carried out in April of this year.

## Materials and Methods

### *The fishing gear*

The experimental work was carried out aboard the F. V. Pennysmart owned and operated by Fishery Products International (FPI) Ltd. The vessel is a 45.73-m stern trawler with 2100 BHP. The vessel was equipped with a 117 Millennium turbot trawl (standard trawl) constructed with meshes 160 mm or more in the fore sections and 145-mm mesh in the extension and the codend (Table 1). For the selectivity experiments, the trawl was divided into two sections or trousers by a 50-mm mesh vertical panel extending the full length of the trawl. One side of the panel was a standard codend with 145-mm mesh size and the other side of the panel was a codend fitted with a small-mesh (50 mm) liner.

At-sea fishing trials were conducted in NAFO Division 3K over the period from 24 April to 03 May 2000. The towing speed for each haul was approximately 3 knots\hour and fishing depths ranged from about 973-1298 m with most tows at about 1 000 m and a few between 1000-1300 m (see Table 2 showing location and depth of each tow). Tow duration was standardized to 4 hours which is typically used in the commercial fishery. In order to monitor the geometry of the gear and ensure that it was operating properly, two tows were completed at the beginning of the sea trials with the gear having 145-mm mesh in both sides of the trouser. Once it was determined that the gear was operating properly, then the liner was installed. Thus the trouser trawl had one codend with 145 mm mesh size (**test codend**) and the other codend with a small-mesh liner of 50 mm mesh to serve as the **control codend**. Selectivity of the standard gear was estimated by comparing the catch of the standard (test) codend with the total population of fish exposed to the gear estimated from the catch of the small-mesh control codend. The codends were rotated midway during the experiment in order to reduce any bias caused by the experimental procedure (ICES, 1996). During the experiment, mesh sizes of all components of the trawl were periodically checked for shrinkage (Table 3).

*Sampling*

As the gear was being hauled, the number of fish captured in each codend of the gear was estimated to determine a) if the tow was valid, i.e. having a minimum of 250 fish in each codend, and b) to determine if there was any damage to the gear that might have influenced the catch performance of the gear. Then the catch in one side of the gear (codend) of the trouser trawl was dumped on the ramp and that section sealed off. The catch from the other side of the trouser was then dumped on the other side of the sealed off section. The fish were kept separate until all the catch were measured and recorded or where necessary, appropriate sampling procedures were adopted.

All fish measurements were made using the fork length. The total number and total weight of fish per trouser were determined using the following divisions 1) small mesh control codend - made up of fish in the codend having a 50 mm mesh liner; and 3) the test codend - made up of fish in the 145 mm codend. At the end of the experiment the 50 mm mesh liner was removed and the trawl was again fished with two codends having 145 mm mesh to monitor performance.

The trouser trawl selectivity data was analyzed using the SELECT model (Millar and Walsh, 1992; ICES, 1996). The catch was scaled where necessary and the catch composition data for both the small mesh control codend and the test codend were compared. The retention probabilities and associated variances were then estimated.

## RESULTS

Greenland halibut in the size range of 26 to 87 cm was the main species caught during the experiment. Table 4 shows a summary of the catch data from the trouser trawl. Catch size varied throughout the experiment and was higher in the control codend than in the test codend. Data recorded for the fourteen valid tows completed over the 6-day period were used to determine the, L25, L50, L75, selectivity factor (SF), and the selection range (SR) of the 145 mm codend. Selection curves were fitted using the p-estimated SELECT model.

Table 5 shows the estimated selectivity parameters and associated variances.. Listed in the table are 1) the values calculated for each tow; 2) the combined values for all tows with depths less than 1024 m (570 fathoms) (depth 1); 3) the combined values for all tows with depths greater than 1024 m (570 fathoms)(depth 2); and, 4) the combined total of all valid tows. Figures 1 to 4 show the various plots of selectivity. Fot the combined total hauls the selectivity parameters for a 145 diamond mesh codend were estimated as follows: L25 = 44.04 cm $\pm$ 0.26, L50 = 47.16 cm $\pm$ 0.36, L75 = 51.45 cm $\pm$ 0.48, a selection range (SR) of 7.41 cm, and a selection factor (SF) of 3.29. The estimated SELECT model split (p) was 0.47 $\pm$ 0.02. Figures 1 to 3 show plots of the deviance residuals (McCullagh and Nelder, 1989) which indicate good fits to the model for all cases. Analysis of the selectivity results of the two different depth ranges showed little variation in selection curves associated with a change in depth (Table 4: Fig. 4).

## DISCUSSION

Yield per recruit and MSY calculations are affected by the growth parameters used in the models which in turn are affected by selectivity (and catchability) of the gears used in a fishery. When a new mesh size is introduced into regulation selectivity analyses are necessary. Greenland halibut selectivity experiments have been carried out to measure selection parameters for codends using a range of mesh sizes from 130 to 145-mm mesh (see Walsh and Hickey, 2000). Table 6 summarizes the available data and it is evident that selection lengths and selection factors increase with increasing mesh size. The decrease in selection range reported here for the 145-mm mesh size results in a sharper selection curve than seen in some of the smaller mesh sizes. Sharper selection curves are probably a result of less variability in mesh shape and opening, thus retaining more marketable fish.

Canada's minimum regulated mesh size of 145-mm and a minimum landing size of 45 cm for Greenland halibut is higher than the NAFO regulated mesh size of 130 mm. The minimum landing size corresponds closely with the 25% selection length (L25) derived from the analysis of 145-mm codend mesh size presented here. The NAFO minimum landing size for Greenland halibut is 30 cm which is close to the L25 for 130 mm NAFO regulated mesh size (de C➔rdenas *et al*., 1995).

In recent years the Greenland halibut stock in NAFO Subarea 2 and Div. 3KLMNO has started to rebuild from the low levels seen in the mid-1990s due to regulation of the fishery and above average year-classes in the period 1993-95 (Bowering *et al*., 20000). Canada's use of a regulated minimum mesh size of 145 mm since the early-1990s and a minimum landing size of 45 cm since the mid-1990s should have had an impact on the rebuilding of this stock through its reduction in the quantities of juveniles being caught.

**Acknowledgements:**

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## References

Bowering, W. R., W. B. Brodie, M. J. Morgan, D. Power, and D. Rivard. 2000. An assessment of Greenland halibut in NAFO Subarea 2 and Divisions 3KLMNO. NAFO SCR Doc., No. 23, Serial No. N4257.

Chumakov, A. V., K. N. Nikeshin, and A. S. Gorshkova 1981. Bottom trawl codend selectivity for Greenland halibut in NAFO Subarea 0 and Division 2H, 2J and 3K. NAFO SCR Doc., No. 81/IX/89.

de Cardenas, E. A. Alo de Melo, S. Iglesias, and F. Saborido. 1995. Selectivity of 130 mm mesh size in deepsea bottom trawl fishery in the NAFO Regulatory Area. NAFO SCR Doc. 95/47, Serial No. N2558.

Huse, I., A. C. Gundersen, and K. H. Nedreaas. 1999. Relative selectivity of Greenland halibut (*Reinhardtius hipoglossoides*, Walbaum) by trawls, longlines, and gillnets. Fisheries Research 44:75-93.

ICES 1996. ICES. Cooperative Research Report No. 215, Manual of Methods of Measuring the Selectivity of Towed Fishing Gears and Methodology Manual: Measurement of Fishing Gear Selectivity

McCullagh, P , and J. A Nelder. 1989. Generalized Linear Models, 2$^{nd}$ edition. Chapman and Hall, 511p.

Millar, R. B., and S. J. Walsh. 1992. Application of trawl selectivity studies with an application to trouser trawls. Fish. Res. 13: 205-220.

Walsh, S. J., and W. H. Hickey. 2000. Review of bottom trawl codend mesh selection studies in the Northwest Atlantic. NAFO SCR Doc. 00/49, Serial No. N4281.

Table 1. Gear Data
117 Millennium Trawl

| | Trouser Trawl |
|---|---|
| Headline Length | 35.8 m |
| Groundrope Length | 56.7 m |
| Codend Extension | 6.28 m |
| Belly Length<br>Front<br>Back | <br>10.6 m<br>9.9 m |
| Nominal mesh size | 200 mm (KC) Wing<br>178 mm (KC) Belly |
| Codend | 145 mm test<br>50 mm |
| Bridle Length | 51.8 m |
| Groundrope | Rockhopper |
| Door | OVAL "Perfect"<br>1600 kg. 5.3². m |

TABLE 2. Location and Depth of Tows.

| Tow# | Tow Locations (degrees & minutes) | | | | Depths. (m) | | Distance Towed (NM) |
|---|---|---|---|---|---|---|---|
| | Nets on Bottom | | Nets off Bottom | | Tow Start | Tow End | |
| | North | West | North | West | | | |
| | | | | | | | |
| 4 | 50.07 | 49.41 | 49.55 | 49.36 | 1273 | 1273 | 12.3 |
| 5 | 49.47 | 49.38 | 49.37 | 49.31 | 1181 | 1255 | 11.53 |
| 6 | 49.31 | 49.29 | 49.19 | 49.31 | 1298 | 1295 | 12.26 |
| 8 | 49.16 | 49.45 | 49.28 | 49.39 | 1035 | 1106 | 12.5 |
| 10 | 49.17 | 49.46 | 49.28 | 49.40 | 1006 | 1085 | 12.1 |
| 11 | 49.29 | 49.40 | 49.18 | 49.45 | 1083 | 1033 | 11.8 |
| 12 | 49.17 | 49.47 | 49.29 | 49.46 | 973 | 962 | 12.1 |
| 13 | 49.32 | 49.44 | 49.43 | 49.46 | 988 | 972 | 11.4 |
| 14 | 49.40 | 49.43 | 49.27 | 49.40 | 1042 | 1083 | 12.8 |
| 15 | 49.23 | 49.42 | 49.35 | 49.44 | 1066 | 982 | 12.2 |
| 16 | 49.29 | 49.45 | 49.16 | 49.46 | 978 | 1011 | 12.4 |
| 19 | 49.19 | 49.44 | 49.31 | 49.40 | 1030 | 1064 | 12.2 |
| 21 | 49.18 | 49.43 | 49.31 | 49.43 | 1019 | 1006 | 12.8 |
| 22 | 49.30 | 49.43 | 49.18 | 49.46 | 1011 | 1002 | 12.3 |

Table 3. Summary of Critical Mesh Size Measurements Taken During the Experimental Trials.

| **Trouser Trawl (Wet Mesh Measurements)** | | | | |
|---|---|---|---|---|
| **Set #** | **Starboard (mm)** | **SD** | **Port side (mm)** | **SD** |
| **Set 2** | **144.1** | **4.52** | **145.9** | **2.60** |
| **Set 13** | **144.3** | **5.02** | **143.2** | **2.95** |
| **Set 22** | **144.8** | **2.33** | **142.8** | **3.49** |
| **Average** | **144.4** | | **144.0** | |
| **Sm. mesh Liner avg.** | **53.9** | | **53.7** | |
| **Extension** | **145.0** | | **145.9** | |
| **2nd Belly** | **163.2** | | **164.2** | |
| **Wings** | **App. 185** | | **App. 185** | |
| **Belly** | **App. 185** | | **App. 185** | |
| **Square** | **App. 185** | | **App. 185** | |

TABLE 4. Summary of catch data from trouser trawls

| | Control Codend (50 mm) | | | | Standard Codend (145 mm) | | | |
|---|---|---|---|---|---|---|---|---|
| Set # | No. Small Fish | Total No. Fish | Wt. Fish (kg) | % Small Fish Retained | No. Small Fish | Total No. Fish caught | Wt. Fish (kg) | % Small Fish Retained |
| 04 | 166 | 251 | 330 | 0.66 | 44 | 159 | 129 | 0.28 |
| 05 | 166 | 272 | 252 | 0.61 | 26 | 151 | 157 | 0.17 |
| 06 | 211 | 312 | 195 | 0.67 | 40 | 136 | 114 | 0.29 |
| 08 | 144 | 263 | 1107 | 0.54 | 85 | 259 | 439 | 0.33 |
| 10 | 168 | 263 | 951 | 0.63 | 35 | 241 | 360 | 0.15 |
| 11 | 158 | 262 | 499 | 0.60 | 31 | 148 | 171 | 0.21 |
| 12 | 185 | 267 | 2647 | 0.69 | 86 | 285 | 823 | 0.30 |
| 13 | 189 | 288 | 1104 | 0.65 | 69 | 267 | 405 | 0.26 |
| 14 | 151 | 268 | 880 | 0.56 | 85 | 322 | 410 | 0.26 |
| 15 | 158 | 291 | 1550 | 0.54 | 42 | 258 | 472 | 0.16 |
| 16 | 168 | 297 | 2865 | 0.56 | 99 | 309 | 844 | 0.32 |
| 19 | 170 | 277 | 819 | 0.61 | 70 | 268 | 312 | 0.26 |
| 21 | 152 | 275 | 2565 | 0.55 | 89 | 273 | 936 | 0.37 |
| 22 | 169 | 272 | 1196 | 0.62 | 58 | 266 | 339 | 0.22 |

Table 5 Logistic estimates of selectivity parameters and associated standard errors(S.E.) from the estimated split (p) SELECT model.

| Set No. | a | a (S.E.) | b | b (S.E.) | p | p (S.E.) | L25 | L25(S.E.) | L50 | L50 (S.E.) | L75 | L75 (S.E) | SR | SF |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | -15.22 | 2.53 | 0.32 | 0.06 | 0.55 | 0.06 | 43.77 | 0.76 | 47.18 | 1.04 | 50.58 | 1.37 | 6.81 | 3.25 |
| 5 | -16.72 | 2.77 | 0.34 | 0.07 | 0.66 | 0.07 | 45.33 | 0.84 | 48.51 | 1.12 | 51.70 | 1.43 | 6.38 | 3.35 |
| 6 | -12.99 | 2.39 | 0.27 | 0.06 | 0.64 | 0.09 | 44.37 | 1.12 | 48.47 | 1.49 | 52.57 | 1.92 | 8.20 | 3.34 |
| 8 | -10.94 | 2.80 | 0.24 | 0.05 | 0.42 | 0.04 | 40.46 | 0.55 | 44.98 | 0.83 | 49.49 | 1.20 | 9.03 | 3.10 |
| 10 | -21.32 | 2.28 | 0.44 | 0.05 | 0.50 | 0.04 | 45.58 | 0.44 | 48.05 | 0.58 | 50.53 | 0.75 | 4.95 | 3.31 |
| 11 | -14.64 | 2.03 | 0.29 | 0.05 | 0.55 | 0.08 | 46.60 | 0.91 | 50.38 | 1.18 | 54.16 | 1.48 | 7.56 | 3.47 |
| 12 | -16.61 | 1.11 | 0.35 | 0.03 | 0.51 | 0.04 | 44.66 | 0.40 | 47.83 | 0.52 | 50.99 | 0.65 | 6.33 | 3.30 |
| 13 | -19.52 | 2.19 | 0.42 | 0.05 | 0.47 | 0.04 | 43.91 | 0.39 | 46.52 | 0.55 | 49.14 | 0.73 | 5.24 | 3.21 |
| 14 | -16.83 | 2.46 | 0.38 | 0.06 | 0.48 | 0.04 | 41.88 | 0.42 | 44.81 | 0.61 | 47.73 | 0.86 | 5.85 | 3.09 |
| 15 | -20.20 | 2.58 | 0.45 | 0.06 | 0.34 | 0.02 | 42.75 | 0.32 | 45.21 | 0.45 | 47.67 | 0.65 | 4.92 | 3.12 |
| 16 | -10.65 | 0.95 | 0.21 | 0.03 | 0.52 | 0.07 | 45.94 | 0.91 | 51.22 | 1.18 | 56.51 | 1.47 | 10.57 | 3.53 |
| 19 | -17.86 | 2.90 | 0.40 | 0.07 | 0.40 | 0.04 | 42.35 | 0.43 | 45.12 | 0.62 | 47.90 | 0.89 | 5.55 | 3.11 |
| 21 | -21.73 | 2.68 | 0.51 | 0.07 | 0.35 | 0.02 | 40.42 | 0.22 | 42.57 | 0.31 | 44.73 | 0.48 | 4.30 | 2.94 |
| 22 | -15.85 | 1.53 | 0.31 | 0.04 | 0.54 | 0.06 | 47.01 | 0.72 | 50.51 | 0.91 | 54.01 | 1.12 | 7.00 | 3.48 |
| depth 1 | -14.02 | 0.43 | 0.29 | 0.01 | 0.46 | 0.01 | 44.08 | 0.17 | 47.83 | 0.23 | 51.57 | 0.30 | 7.49 | 3.30 |
| depth 2 | -14.82 | 0.79 | 0.32 | 0.02 | 0.49 | 0.02 | 43.42 | 0.21 | 46.90 | 0.30 | 50.38 | 0.40 | 6.95 | 3.23 |
| combined | -14.16 | 0.37 | 0.30 | 0.01 | 0.47 | 0.01 | 44.04 | 0.13 | 47.74 | 0.18 | 51.45 | 0.24 | 7.41 | 3.29 |

Table 6. Comparison of selectivity parameters derived from various codend mesh sizes.

| Mesh size (mm) | No. Hauls | Tow duration hrs. | L25 (cm) | L50 (cm) | L75 (cm) | SR | SF | Reference |
|---|---|---|---|---|---|---|---|---|
| **130** | 4 | 1 | 34.53 | 38.69 | 41.93 | 7.5 | 2.99 | 1 |
| **130** | 2 | 4 | 30.46 | 37.68 | 42.26 | 11.8 | 2.91 | 1 |
| **133** | ? | ? | ? | 40.50 | ? | ? | 3.08 | 2 |
| **135** | 14 | 4 | 37.20 | 42.00 | 46.80 | 9.6 | 3.1 | 3 |
| **145** | 14 | 4 | 44.04 | 47.74 | 51.45 | 7.41 | 3.29 | *This study* |

[1]de Cárdenas et al. 1995

[2]Chumakov et al. 1981

[3]Huse et al 1999

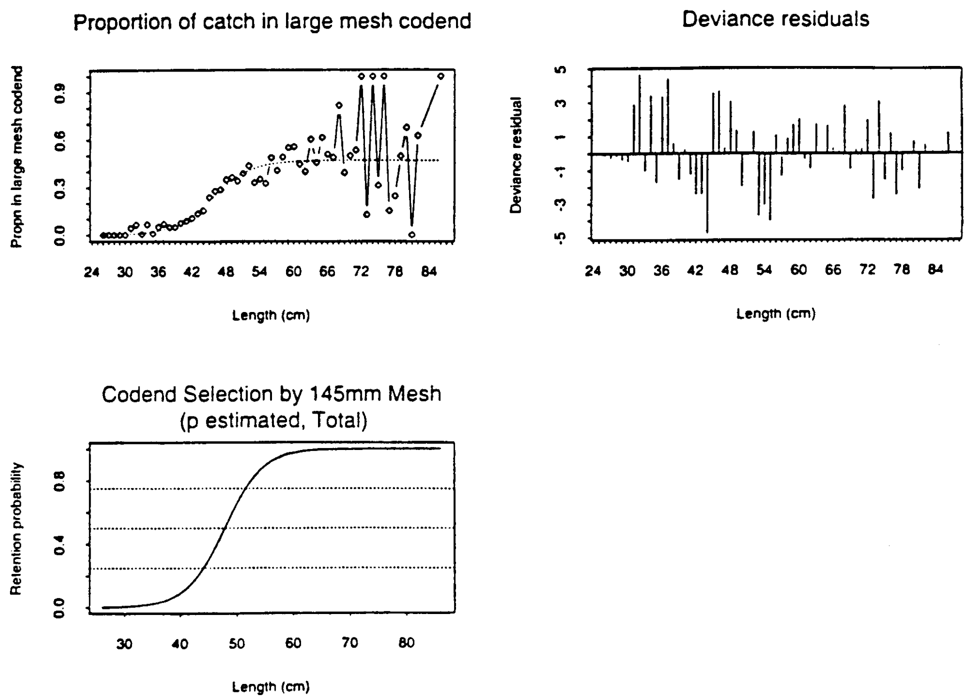


Fig. 1. Plot of fitted logistic selectivity curves for the combined 14 hauls.

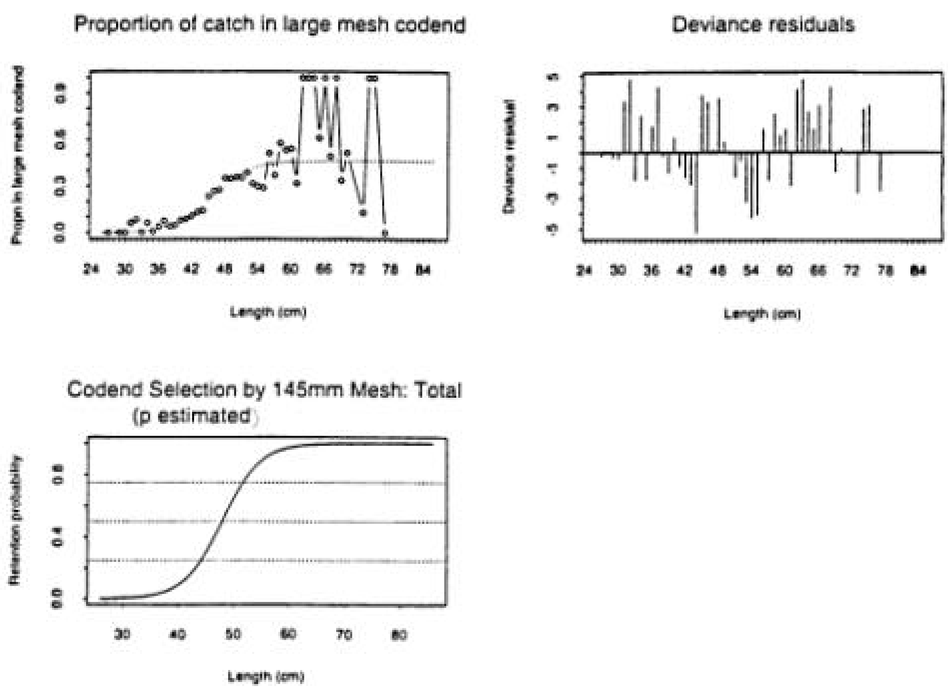


Fig. 2. Plot of fitted logistic selectivity curves for hauls less than 1024 m (570 fathoms).

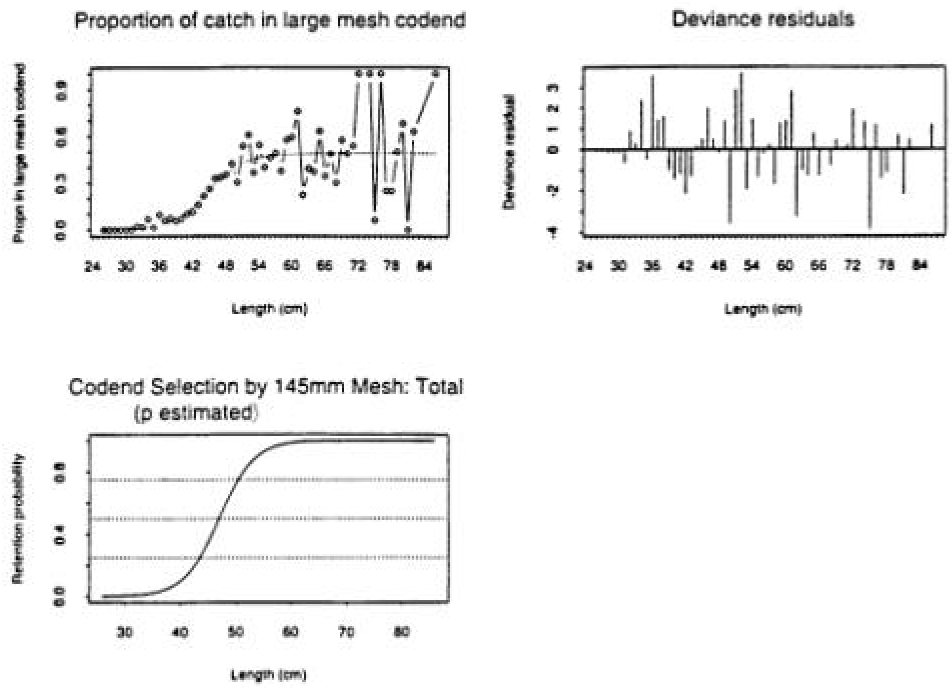


Fig. 3. Plot of fitted logistic selectivity curve derived from the hauls with depths greater than 1024 m (570 fathoms).

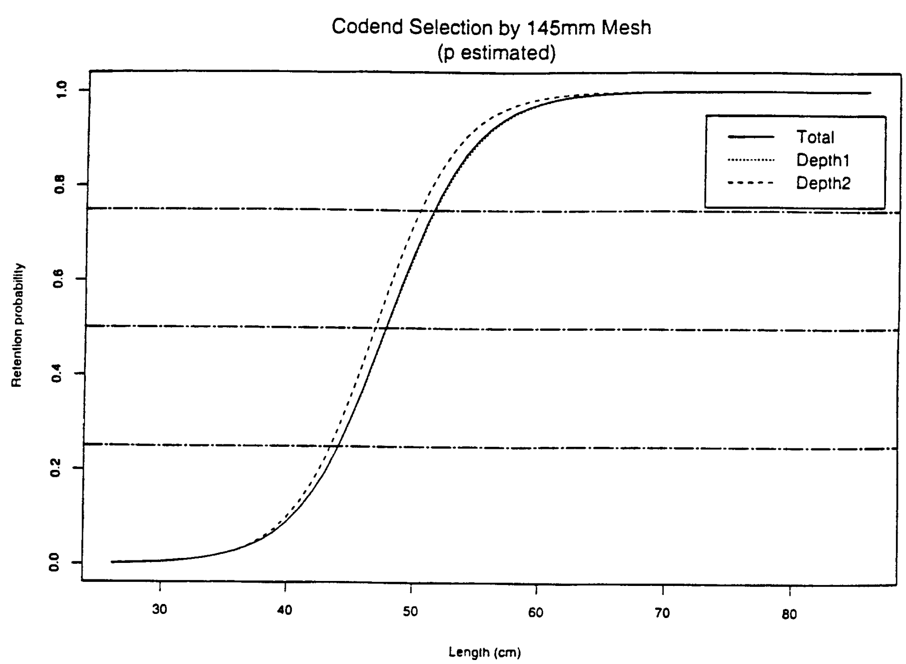


Fig . 4. Selection of Greenland halibut in 145 mm diamond mesh codends.