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SELECTIVITY EXPERIENCES ON HAKE (*Merluccius hubbsi*) BY MEANS THE USE OF A SINGLE GRID SORTING DEVICE FOR THE ESCAPE OF JUVENILE FISHES FROM TRAWLS (DEJUPA)

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ABSTRACT

This work deals with the development of a device consisting on an extension piece installed between the body and the codend of trawlnets to allow juvenile fish escapement before they enter the codend of the trawlnet. Selectivity estimates on common hake obtained with the application of this device in the Argentine Atlantic Southwest fishery are also reported. Design and construction were started in October 1995, and two comparative fishing experiences with alternate hauls with the device were carried out aboard the FRV "**Dr. Eduardo Holmberg**" in June 1996 and April-May 1997, respectively. In the first cruise very low hake densities were found (less than 350 kg per tow), and the escape percentage was 90% for juveniles 35 cm (total length) or shorter; this being accepted as the first maturity length for the species. In the second cruise , with higher densities (up to 3000 kg per haul approximately) the escape percentage was 61% for alternate hauls and 58% with a retention codend in the DEJUPA grid. The latter value is 61% if only the haul where the grid retention codend worked best and where sampling was most efficient is considered. In all experiences carried out with the grid with an inter-rod distance of 33 mm , retention values of 50% close to the first maturity length , were obtained. The DEJUPA, whose invention patent has been requested by the National Institute of Fisheries Research and Development (INIDEP) to the National Institute of Industrial Property, has achieved such selectivity conditions that enable it to act as an important complement for the 120 mm diamond mesh established as obligatory in the hake fishery, or as a selectivity gear independent of codend mesh sizes.

Keywords: hake selectivity, sorting grid device, trawl selectivity

INTRODUCTION

Trawlnets used for the capture of several fish species allow the higher escape of juveniles through the meshes of the codend (Fridman *et al*, 1973; Wileman *et al, 1996*). Taking this into consideration, selectivity studies intended to determine the minimum measure or opening that the codend meshes of trawlnets capturing commercial species should have are carried out. The nets are constructed with netting pieces made of synthetic fibres and generally equal in their four sides, arranged so as to show a rhomboid-or diamond shape in the towing direction. In this way, when subjected to the tensions of tow they tend to close, thereby decreasing their opening. While the codend is being filled, the meshes become obstructed by fish, which may become entangled or jammed in the meshes. Both phenomena combined produce a deficient escape of specimens as a function of their length, gradually diminishing gear selectivity as a function of the catch (Ehrhardt *et al.*, 1996; Erickson *et al.*, 1996). As a consequence resource overexploitation is augmented by the extraction of juveniles smaller than the length-at-first-capture or the first maturity length of the species. This situation is being tackled internationally by the use of square meshes in several sectors of the net, for their opening is not influenced by the tensions of the system (Robertson, 1993). Experiences with this kind of gear have been carried out with no positive results in our fishery. This is probably due to the fact that the square mesh panels were located only in the front part of the bag; a greater surface of the bag might have to be furnished with these meshes (Ehrhardt *et al.*, 1996). This step is considered necessary according to the characteristics of the argentine fishery, basically as a function of the high catches per haul obtained by the bigger ships of the fishing fleet, which also constitute the main sector. The curves which relate fish retention percentage as a function of total length for a determinate measure of the codend mesh are adjusted by means of several mathematical models (Wileman *et al*, 1996) and show among other parameters which is the fish size corresponding to 50% retention, which normally coincides with the length-at-first-capture of the species. In this way, below 50% retention less juveniles are caught as size decreases and above 50% more adults of higher size are caught until total retention is reached. The retention or selectivity curves obtained by the use of square meshes are closer to the ideal situation than those obtained through the use of rhomboid or diamond-shaped meshes. Ideally, all juveniles of length equal to the first capture length or shorter should escape from the mesh codend ; all fish larger than this should be retained.

Fish filtration systems by grids constructed with resistant elements get closer to the ideal situation, for in this case no deformities due to the trawl tension exist, and entanglement is highly eliminated, with the consequent decrease in grids obstruction. In this way, metallic grids achieve a very efficient size selectivity as a function of the inter-rod separation distance.

Based upon these principles, nowadays grid devices are being developed, which allow a closer approach to the ideal selectivity by their own action or as a complement of codends, allowing fish juveniles to escape before entering the codend (Larsen & Isaksen, 1993).

Besides, Pikitch *et al.* (1995) suggest that the deleterious effect of the meshes and their blocking with increasing catches can be reduced or eliminated by the use of such devices as already described.

MATERIAL AND METHODS

The device for fish juvenile escape in trawlnets, as shown in Fig. 1, is a cylindrical extension piece (1) constructed with net meshes knit with synthetic fibres, added to the trawlnet between the body and the codend by means of the unions (2) and (11) respectively, and by the reinforcing ropes (3). Work done by the device during the fishing operation is based on the principle of fish filtering through metallic grids or any other resistant material. During tow, the catch entering the net gets to the device and passes to the truncate cone-shaped guide funnel (4) which directs it to the grid base (5). This is installed at a certain angle respect the horizontal plane and has at the lower part a number of rods (6) separated at equal distances from each other, and at the upper part a rod-free frame constituting the hole (7). From the grid base (5) fishes go through the grid's rods upwards, passing through them according to their size to go outside using the fish outlet (12) on both sides of the grid, or simply going through the hole (7) to the interior of the codend or to the bag of the net. This is achieved by the installation of a separating panel (8) that avoid the mixing of escaping and codend-going fishes. At the sides and in the upper external part of the grid buoys (9) are installed to compensate for the grid's weight and also a mooring rope on both sides (10) which helps keep the device at the right angle respect to the horizontal plane.

The device designed to function as already described was calculated and constructed according to the dimensions shown in Fig. 2 and tested aboard the FRV "**Dr. Eduardo L. Holmberg**", a stern trawler-purse- seiner of 2100 HP and 1000 GRT.

Two comparative fishing experiences with alternate hauls were carried out during the cruises H-08/96 and H-04/97 between 06/03/96 and 06-09/96 and between 04/25/97 and 05/12/97, respectively, in the fishing grounds shown in Fig. 3.

The trawlnet used in both cruises is made up of polyamide twine (nylon) and its design corresponds basically to a two-panel Engel-Net type with a length of 35.50 m and 50 m headline and groundrope, respectively. Codends used in both cases were blinded with polyethylene panels with meshes smaller than those at the codend, with the aim of capturing fishes of all lengths entering the net. From the June 1996 experiences 8 alternate comparative hauls with and without DEJUPA with a 33 mm-inter-rod grid were considered. 16 alternate comparative fishing hauls with and without DEJUPA and a haul with a retention codend of design improvised in the DEJUPA grid, accomplished in May 1997. With the aim of comparing the DEJUPA results 9 hauls from the hake selectivity cruise from August 1994 were considered, carried out in the area shown in Fig. 3. In this opportunity the same net as in the previous cases with a 120 mm mesh codend with retention codend according to the designs recommended by Pope *et al.* (1983).

Each selectivity curve was assigned a colour and a number, in the following way: red=1, green= 2, yellow= 3 and blue= 4.

Selectivity estimates in cases where retention codends were used was statistically modelled according to the logistic model given by Sparre *et al*, 1983. The parameters were calculated using the maximum likelihood method (MLL) by mean the "Solver" add-in soft MS-Excel:

$$S(l) = 1/[1+\exp(a+b*l)]$$

where $S(l)$= selectivity or retention percentage;

l = length class;

a, b = parameters to estimate

Selectivity estimates during comparative fishing experiments with alternate hauls was statistically modelled for a logistic function, according with the SELECT method (Millar 1992; Millar & Walsh, 1992). The parameters were calculated using the maximum likelihood method (MLL) by means the "Solver" add-in soft MS-Excel:

$$\phi(l) = p\exp(a+bl)/[(1-p)+\exp(a+bl)] \qquad \text{(a)}$$

where $\Phi(l)$= selectivity;

p = retention probability;

For the yellow selectivity curve (3) expression (a) was used, with an estimate of p, and for the blue selectivity curve (4) the following model was applied with p=0.5.

$$\phi(l) = \exp(a+bl) / [1 + 2\exp(a+bl)]$$

Model selection for the alternate hauls was carried out by AIC application.(Akaike, 1976).

The data on maximum width of retained fish were statistically modelled according to the classical lineal relationships of the expression, as a function of length.

Y = a + bX

In the applied equation Y is the perimeter or maximum fish width , X is the length, while a and b are the equation parameters directly adjusted by means of minimum square algorithms.

RESULTS

Retention curves shown in Fig. 4 were achieved with data obtained in different selectivity cruises described above. In the graph we show in red (1) the selectivity produced by the 120 mm diamond mesh in August 1994 taking 9 hauls in a total catch per tow range of 1000 to 3000 kg of hake, with a mean CPUE (Catch per unit effort) of 33.65 kg/min (kilograms per minute of tow).

In green (2) we show the retention curve corresponding to one haul for DEJUPA in May 1997, with an improvised design retention codend in the grid and with a total capture of 1743.6 kg of hake and a CPUE of 18.5 kg/min.. It must be noted that two hauls were carried out with the retention codend in the grid and that the escape result between them, by direct comparison, was 58% for 35 cm juveniles or smaller, but subsequent analyses indicated the need to discard the first haul because fishes from the codend were mixed with those from the grid retention codend. In the second haul the codend retention design was improved and all specimens from the codend were separated carefully before opening and sampling the grid retention codend . By this reason only this haul was considered for the final evaluation.

The retention curve corresponding to 16 alternate comparative hauls carried out in May 1997, with total capture per tow values ranging from 1000 to 3000 kg hake is shown in yellow (3). In the 8 hauls without DEJUPA mean CPUE in kg/min was 30.21 while in the 8 hauls with DEJUPA it was 17.95. This difference shows the amount of juvenile escapement produced by the use of DEJUPA.

The retention curve corresponding to 8 alternate comparative hauls carried out in June 1996 with low hake densities (less than 350 kg per haul) is shown in blue (4), with a mean CPUE of 3.37 kg/min for 4 hauls without DEJUPA and 1.77 for the same number of hauls with DEJUPA.

In Figs. 5 and 6 hake size distributions corresponding to the retention curves shown in Fig. 4 may be seen. Table 1 shows values for 50% retention length or size in cm (L_{50}), the selectivity range in cm (SR), and the total number of hake specimens sampled. The escape percentage and the percentage 35 cm hake juveniles or smaller in the total catch determined by direct comparison for each distribution are also shown

Figure 7 shows the regression of maximum width of retained fish as a function of size for n=877 specimens. The function shows that for a 35 cm length a maximum width of 33 mm may be estimated. This measure coincides with the inter-rod separation of the grid used in the DEJUPA, previously estimated through perimeter values of the species.

DISCUSSION

With the results described we discuss some comparative analyses between the experiences, highlighting the following aspects:

a) The differences observed among the retention curves of May 1997 , green (2) and yellow (3) colors, may be attributable to the dissimilar methodologies used for catches and their processing. According to Pope *et al.* (1983) with the covered codend method it is possible to get results with only a single haul; escapement is really appreciated, since each tow is a complete experiment in itself and allows to make an absolute estimation, instead of a comparative one. In our case in particular a retention codend was used to capture fishes escaping through the grid, installed inside the blinded codend to replace the separating netting. The result of the corresponding retention curve, green color (2), adjusted to that previously mentioned.

b) The retention curve obtained by means of alternate tows in the June 1996 cruise (blue color 4) shows differences in the selectivity variables with respect to that obtained in May 1997 (yellow color 3), though the same methodology was used. This could be caused by a slight difference in size distribution and fundamentally in the huge CPUE mean variation in the tows and in the number of specimens considered.

c) Retention curves from experiences with DEJUPA with retention codend in the grid (green color 2) in May 1997 and the retention curve obtained in experiences carried out with 120 mm diamond mesh with the covered codend method in August 1994 (red color 1) are compared. Fundamentally, there is a difference in the L_{50} and SR values which indicate a better selective behaviour of the DEJUPA for the escape of 35 cm juveniles or smaller. Part of this difference may be attributed to different length distributions found when experiences were carried out, which result in juvenile percentages of 75% and 44% of catch composition, and mean CPUEs of 18.5 kg/min and 33.65 kg/min, respectively, even though hauls remained in a catch range of 1000 to 3000 kg in both cases.

d) L_{50} and juvenile percent escapement differences between the green(2) and blue(4) retention curves, both obtained through the use of DEJUPA, could be the consequence of a decrease in gear selectivity caused by higher catch and CPUE values.

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August '94 - Mesh 120 mm with cover (red - 1)		June '96 - Alternate hauls-DEJUPA (blue - 4)	
Quantity of hauls	9	Quantity of hauls	8
Numbers of hake	53.846	Numbers of hake	3.203
% escape <= 35 cm TL	51	% escape <= 35 cm TL	90
% catch composition <= 35 cm TL	44	% catch composition <= 35 cm TL	78
L 50 (cm)	26,7	L 50 (cm)	37,2
S.R. (cm)	16,2	S.R. (cm)	7,8
CPUE Average (Kg/min)	33,65	CPUE Average (Kg/min)	3,37 y 1,77
Catch Range by haul (Kg)	1000 to 3000	Catch Range by haul (Kg)	< 350
May '97 Alternate hauls - DEJUPA - (yellow - 3)		**May '97 - DEJUPA Retention codend (green - 2)**	
Quantity of hauls	16	Quantity of hauls	1
Numbers of hake	102.630	Numbers of hake	5.482
% escape <= 35 cm TL	61	% escape <= 35 cm TL	61
% catch composition <= 35 cm TL	75	% catch composition <= 35 cm TL	75
L 50 (cm)	36	L 50 (cm)	34,7
S.R. (cm)	17,3	S.R. (cm)	8,2
CPUE Average (Kg/min)	30,21 y 17,95	CPUE (Kg/min)	18,5
Catch Range by haul (Kg)	1000 to 3000	Catch (Kg)	1743,6

Table 1. Results from selection curves and length distribution.

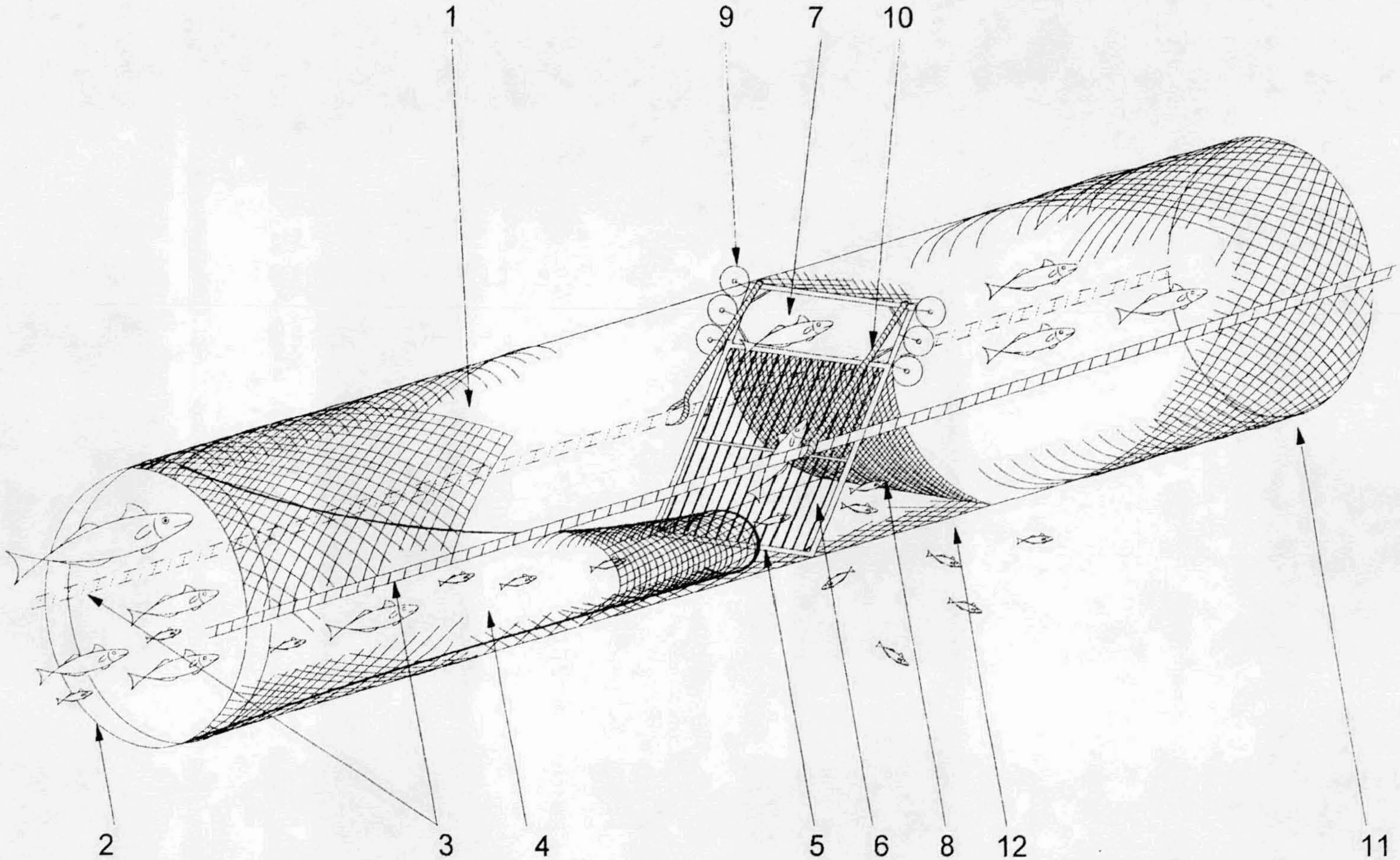
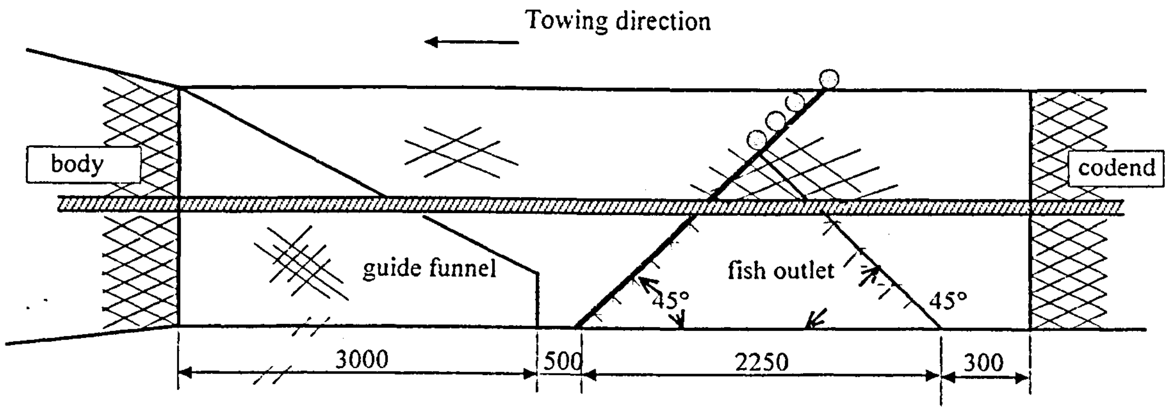
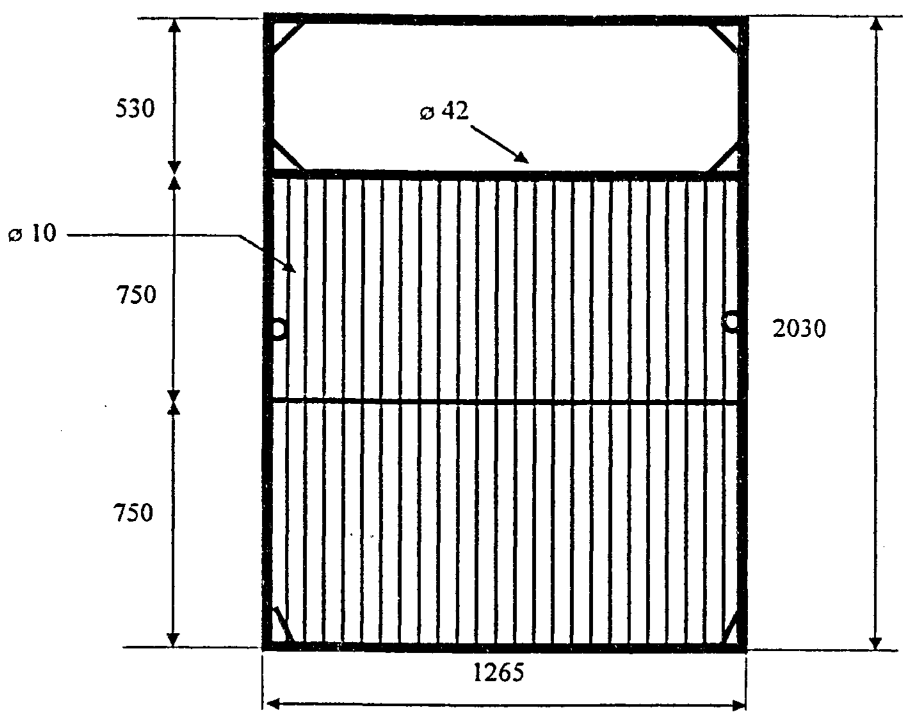


Figure 1. DEJUPA - Single Grid Sorting Device for the Escape of Juvenile Fishes From Trawls.

Lateral view of DEJUPA



DEJUPA Grid



Guide funnel

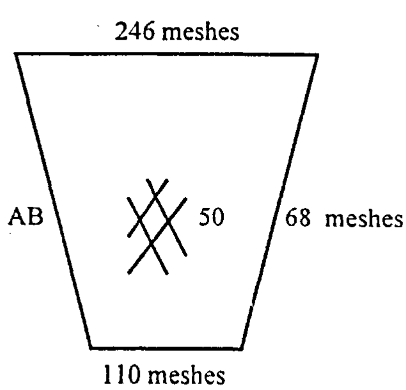


Figure 2. Dimensions (mm) of the single grid sorting device (DEJUPA) used during trials.

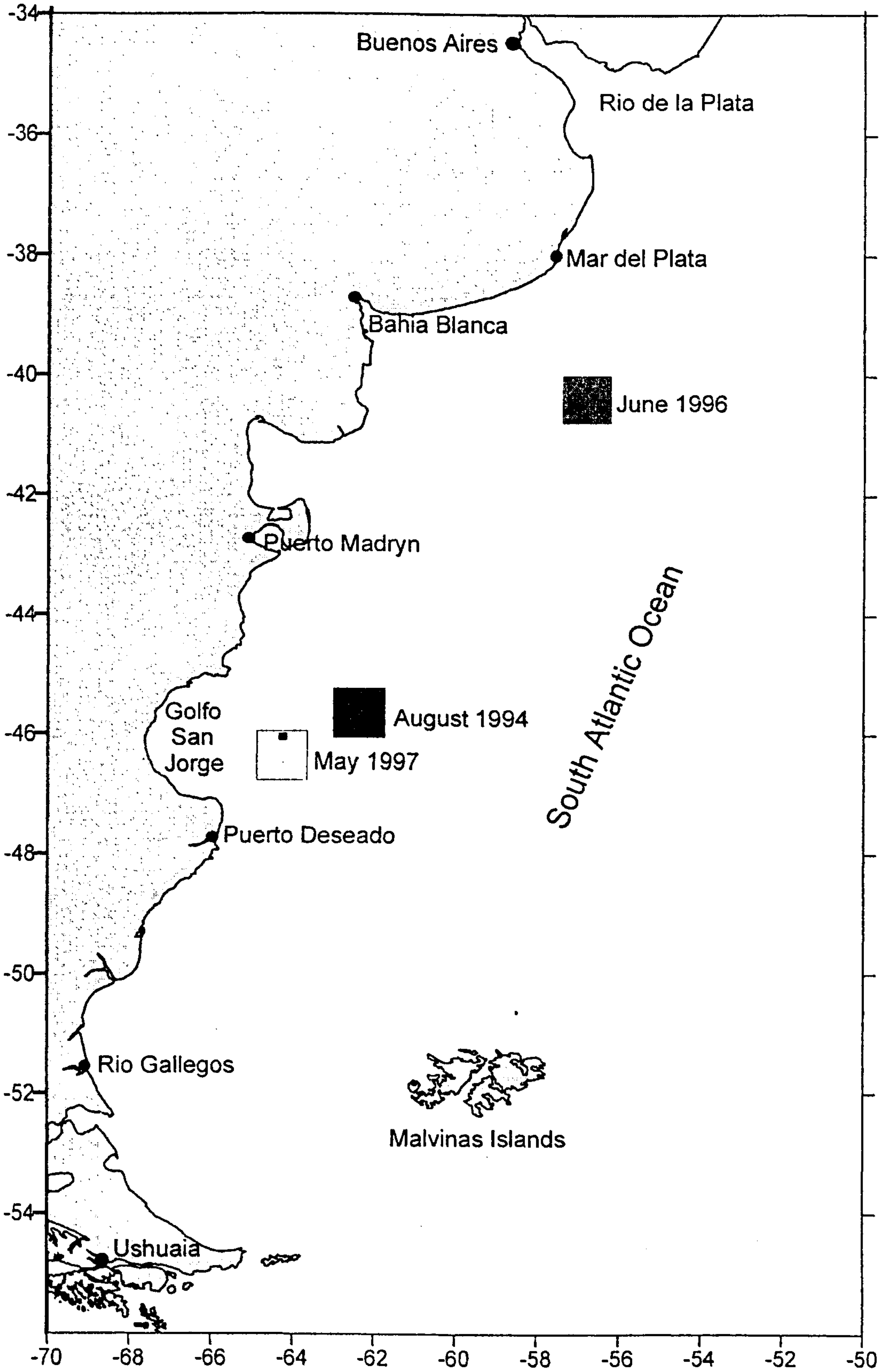


Figure 3. Location of the fishing zone in the three surveys.

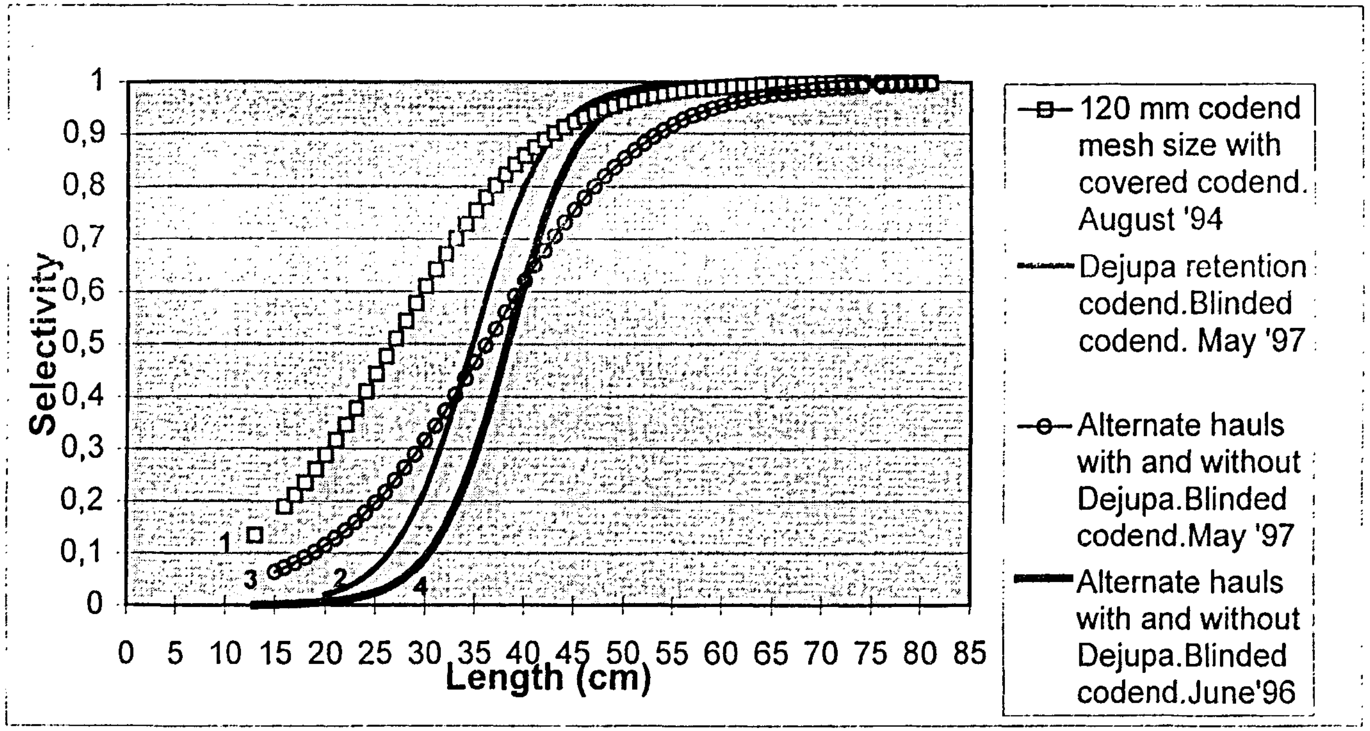
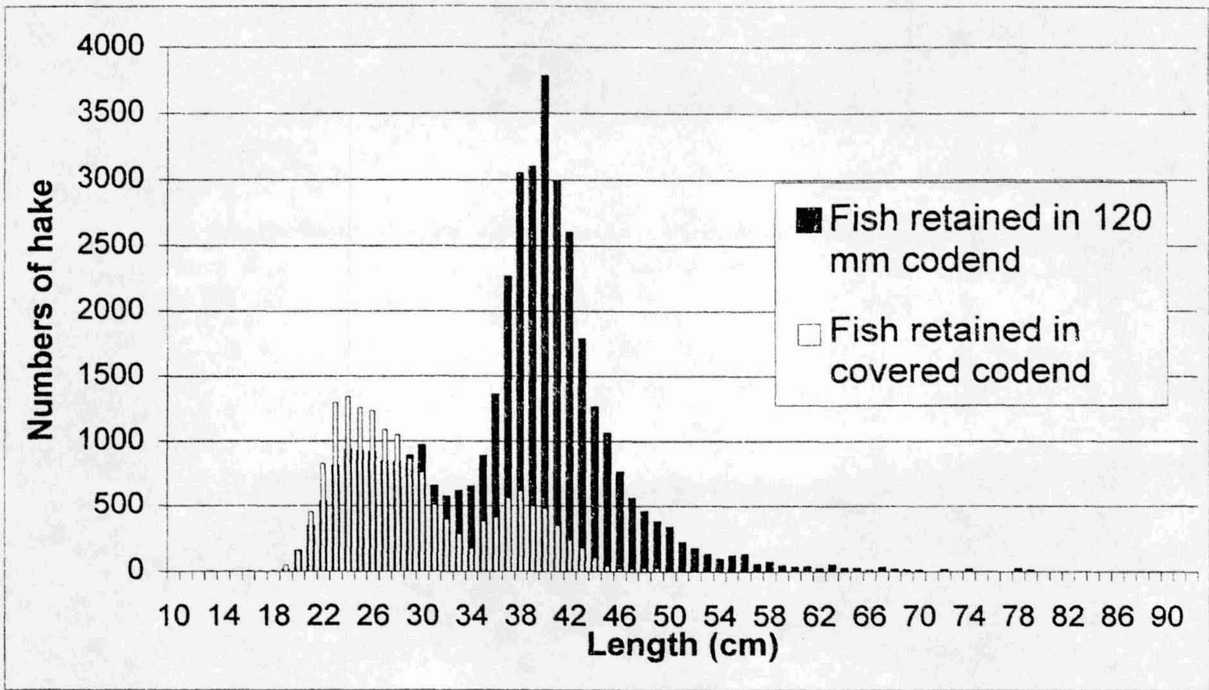
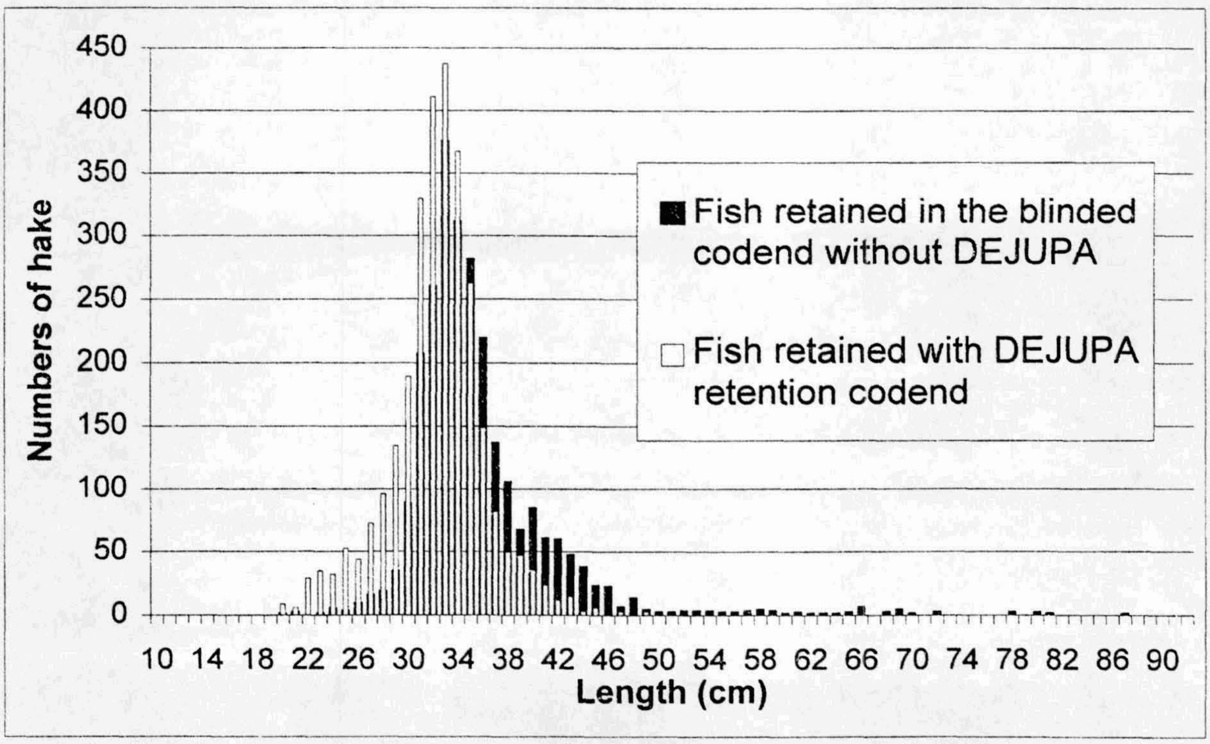


Figure 4. Maximun likelihood method fitting selection curves to covered codend data and "paired gear" data.

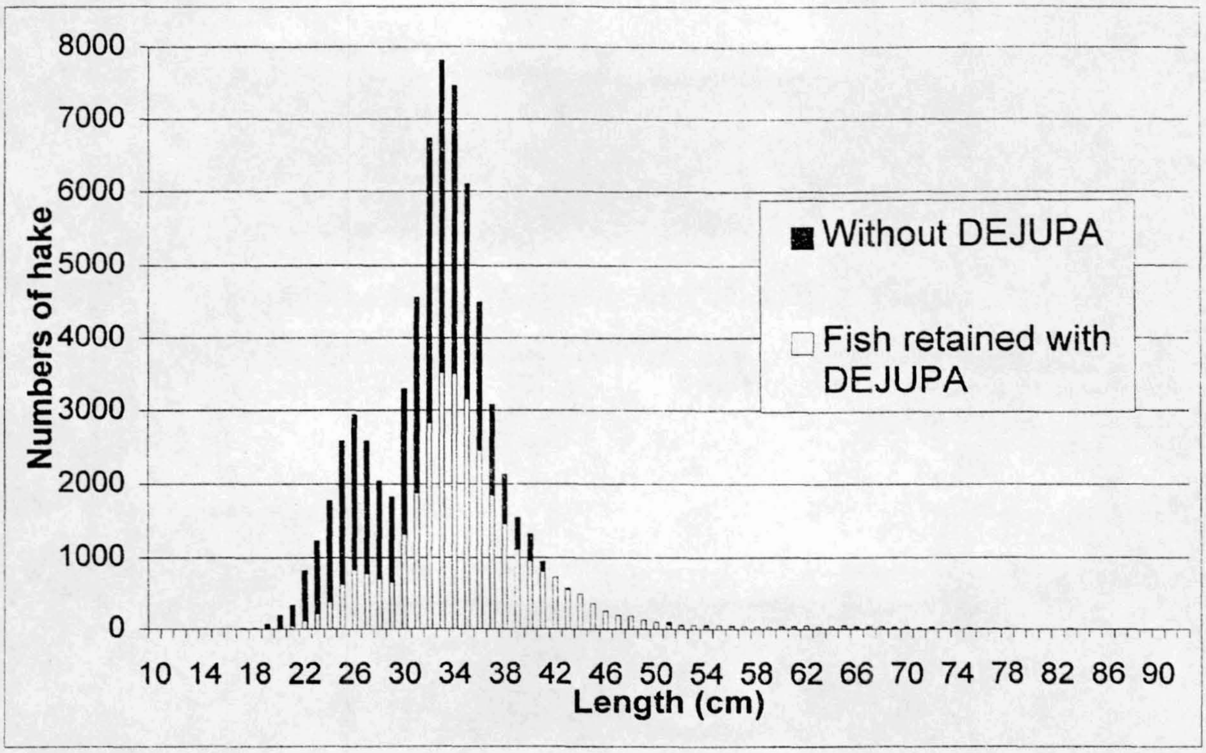


Length distribution of hake in the 120 mm mesh size codend and covered. August '94. (9 hauls) - Red (1)

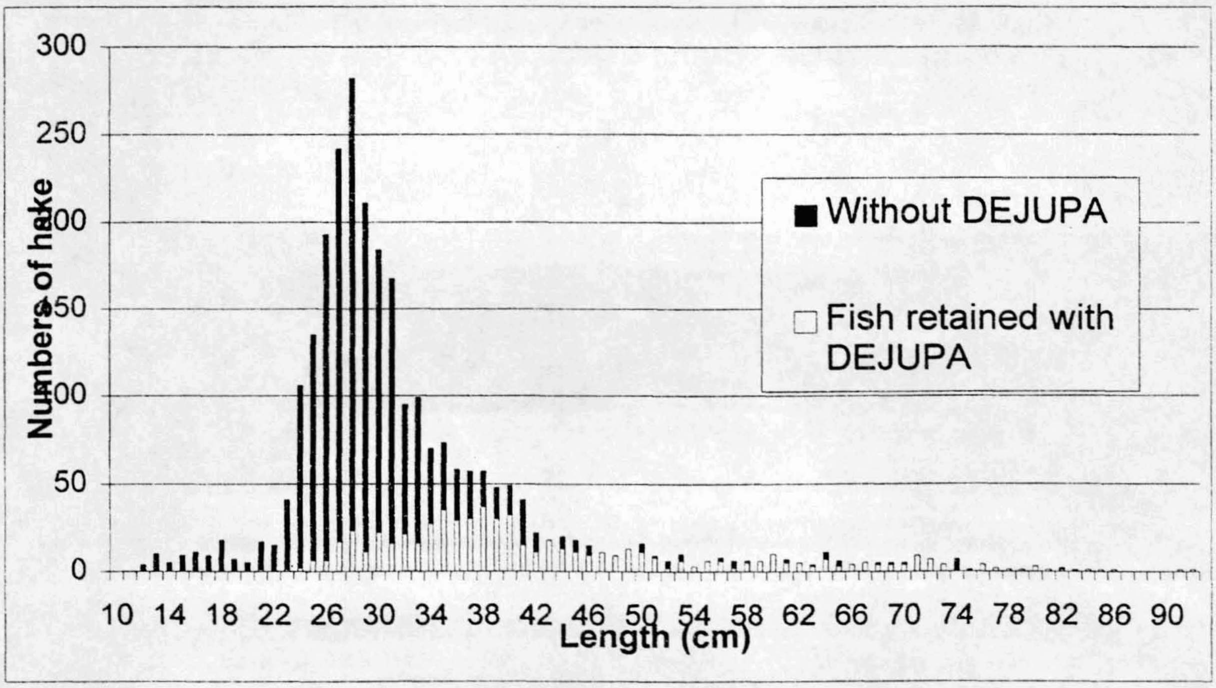


Length distribution of hake in the blinded codend and DEJUPA retention codend. May '97. (1 haul) - Green (2)

Figure 5



Length distribution of hake in the blinded codend with and without DEJUPA. May' 97.(16 hauls) - yellow (3)



Length distribution of hake in the blinded codend with and without DEJUPA. June '96.(8 hauls) - blue (4)

Figure 6

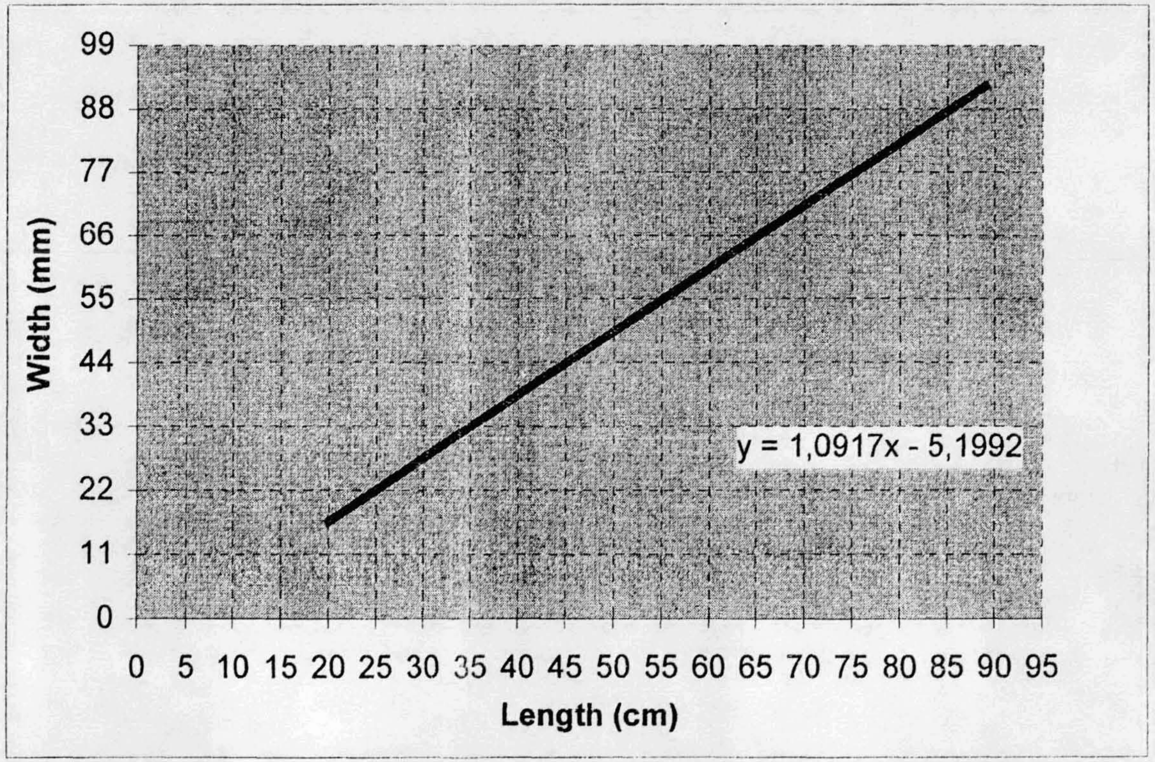


Figure 7. Maximun body width/length relationship of Argentine hake. N=877.