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Temporal and Spatial Variation in Length at Maturity in 3LM and 3NO Greenland halibut

by

S. Junquera and F. Saborido-Rey

Instituto Español de Oceanografia
Instituto de Investigaciones Marinas, Vigo, Spain

Introduction

It is essential for stock management to be able to determine the length or age of fish maturity. This parameter has already been estimated for the Greenland halibut stock in different NAFO areas and time periods (Bowering 1983; Serebryakov *et al.*, 1992; Junquera and Zamarro 1994; Jorgensen and Boje 1994).

In recent years, two features are remarkable in the Greenland halibut stock in Subareas 2 and 3: one is the apparent reduction in stock abundance, shown by the results of the Canadian surveys (Bowering *et al.*, 1993; Bowering *et al.*, 1994; Morgan *et al.*, 1994). The other is that there are indications of a major redistribution of the stock (Anon., 1994; Junquera, 1994) with the presence of adult fish in areas where only juveniles were previously found. It is a known fact that a reduction in population densities affect the reproductive parameters, mainly the length at maturity (Wootton, 1990). This paper reviews the trends for this parameter from 1990 to the present, with a view to evaluating the effect of these events in the stock.

Material and methods

The data used come from the observers on board Spanish commercial deep-water trawlers fleet, from May 1990 until December 1994 (Fig.1). Sampling depth ranged from 800 to 1700 m. Length of fish was recorded as total length and the stage of female maturity was determined visually according to a four-level maturation scale: Stage 1. IMMATURE; Stage 2. RESTING and MATURING; Stage 3. SPAWNING; Stage 4. SPENT.

Females maturity-at-length data from 1990 (Div. 3LM), 1991 (Div. 3LM), 1992 (Div. 3LM and 3NO), 1993 (Div. 3LM and 3 NO) and 1994 (Div. 3LM and 3NO) were used to generate maturity curves. Fish were considered immature if they had ovaries in stage 1 and mature in stage 2, 3 or 4. All curves were adjusted to a logistic equation, and using the logit transformation (Ashton, 1972) the coefficients a and b were calculated. Thus, the size at maturity could be estimated as the minus ratio of coefficients (- a / b). Goodness-of-fit was tested with the likelihood ratio Chi-square (G^2) (Dixon *et al.*, 1990):

$$G^2 = 2\sum O\ln(O/E)$$

where O is the observed frequence and E the expected one.

BMDP LR (Dixon *et al.*, 1990) was used to calculate the predicted values and the coefficients.

To analyze the variation in L_{50} between years and geographic areas, the variance between the respective L_{50} has been obtained from the variances and covariances of the coeficients and (Ashton, 1972):

$$V(L_{50}) = \frac{1}{\beta^2}\left[V(\alpha) + \frac{\alpha^2}{\beta^2}V(\beta) - \frac{2\alpha}{\beta}\operatorname{cov}(\alpha,\beta)\right]$$

Assuming that the estimates of L_{50} are normally distributed, then the Z statistic:

$$Z = \frac{\frac{\alpha_1}{\beta_1} - \frac{\alpha_2}{\beta_2}}{\sqrt{V_1 + V_2}}$$

can be used to test the null hypothesis of the absence of difference in the L_{50} by either year or division (Gunderson, 1977).

Results

The goodness-of-fit for maturity curves (Fig.2) were significant in all the cases considered ($P < 0.05$). A shift to the right can be observed in the curves from 3NO, particularly in 1993 and 1994, while the curves from 3LM remain very similar from 1990 to 1994.

Within areas, the length at 50 % maturity (L_{50} varied very little in the northern ones (Div. 3LM) (Table 1), with a maximum of 69.52 cm in 1991 an a minimum of 64.50 cm in 1994. Differences in size at maturity in this area were not significant in any case (Table 2). Conversely, in the southern areas (3NO), a continuous decrease in the L_{50} is observed during the period analyzed (Table 3), from 59.62 cm in 1992 to 49.71 cm in 1994. Differences in L_{50} between years in this area are all significant, excepting between 1992 and 1993 (Table 4).

When comparing the L_{50} size between areas, the Z values obtained are -4.35 in 1992; -5.31 in 1993 and - 63.58 in 1994; all of them significant at any level. L_{50} is always smaller in 3NO than in 3LM.

Discussion

On the basis of the data analyzed here, it may be concluded that there is a clear difference in the length of 50 % maturity between the northern Flemish Pass (Div. 3LM) and the Div. 3NO, where L_{50} showed to be significantly lower. The discrepancy in the L_{50} between areas is more pronounced in the last year. Bowering (1983) analysed the geographical variation in L_{50} in seven areas, from Subarea 0 to 3 and the Gulf of St. Lawrence. He found that the size and age at maturity decreased significantly from the south to the north, with values ranging from 60.7 cm to 78.85 cm for the northwest Newfoundland shelf and Labrador, and 58.07 for the Gulf of St. Lawrence, where the maturity curve differed significantly from those of the other areas. Similar results are reported by Serebryakov *et al.*, (1992) for Subareas 0 and 1 and Div. 2GH and 2J and the period 1970 - 88. The results obtained here from the northern Flemish Pass are somewhat lower than the ones reported by Bowering (1983) for the closer areas, but are similar to the L_{50} obtained by Jorgensen and Boje (1994) in West Greenland (65 cm), and to the ones previously reported for this same area (Junquera and Zamarro 1994). The homogeneity of the L_{50} sizes estimated supports not only the congruency of the results but also indicates that this parameter is currently stable in this area.

Conversely, a significant decrease in the L_{50} length is observed in Div. 3NO throughout the period of time analysed. The presence of adult Greenland halibut in those areas was first detected in late 1992 as a result of the extension to the south of the fishing area of the EC deep-water trawler fleet. Only juveniles were found there before (Junquera *et al.*, 1992). For management purposes, the Greenland halibut in the areas analysed here is taken as a single stock. According to the Canadian surveys, the biomass indices for Greenland halibut has been declining since the early 80s in Subareas 2 and 3, currently reaching historical minimums (Bowering *et al.*, 1994; Morgan *et al.*, 1994; Bowering *et al.*, 1993). It is known that reduced population densities affect biological parameters, including the reproductive ones: Bagenal (1963) related fluctuations in fecundity of witch flounder with changes in population density, which in turn produces variations in food supply. The reduction of the size at maturity as a consequence of the reduction in population densities has been described in several species: Pitt (1975) in American plaice, Saborido-Rey (1994) in redfish, Templeman and Bishop (1979) in haddock, Kovtsova and Nizovtsev (1985) in Greendland halibut from the Barents sea, and others. It could be assumed that the observed declining trend in the L_{50} in Div. 3NO is a response to a decline in stock abundance, but then the question arises of why this same situation does not occur in the northern Flemish Pass. Bowering (1983) indicates that the Greenland halibut from Gulf of St. Lawrence matures earlier than fish from other areas due to a higher growth rate. No information is available showing a comparison of growth patterns in both the northern Flemish Pass and Div. 3NO, but in any case the results obtained suggest that those areas could be inhabited by groups of relatively isolated fish, where biological parameters respond in different ways which are not only affected by density dependent factors but also by environmental ones.

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Table 1.- Logistic analysis of sexual maturity in Greendland halibut female in Divisions 3LM (1990-94). a= intercept; b=slope; E(b)= Standard error of b; V(L_{50})= Variance of L_{50}; L_{50}= Size at maturity.

	1990	1991	1992	1993	1994
a	-12.0800	-6.7390	-6.4570	-7.6110	-5.5590
b	0.1789	0.0969	0.0990	0.1161	0.0862
E(b)	0.0025	0.0008	0.0006	0.0014	0.0011
V(L_{50})	1.3940	1.2867	1.6213	2.1792	2.1925
L_{50}	67.52	69.52	65.23	65.56	64.50
Size range	13-103	16-120	14-120	21-103	16-103
Number	33581	107227	164818	40136	42558

Table 2.- Estimated values of Z statistic to compare size at maturity in Division 3LM.

	1990	1991	1992	1993
1991	1.2175			
1992	-1.3216	-2.5148		
1993	-1.0412	-2.1280	0.1676	
1994	-1.5943	-2.6874	-0.3709	-0.5027

Table 3.- Logistic analysis of sexual maturity in Greendland halibut female in Divisions 3NO (1990-94). a = intercept; b = slope; E(b) = Standard error of b; $V(L_{50})$ = Variance of L_{50};; L_{50} = Size at maturity.

	1992	1993	1994
a	-14.3200	-8.6630	-5.4580
b	0.2402	0.1505	0.1098
E(b)	0.0050	0.0020	0.0016
$V(L_{50})$	0.0364	2.2278	2.0111
L_{50}	59.62	57.56	49.71
Size range	22-110	15-108	16-110
Number	10365	25306	23684

Table 4.- .- Estimated values of Z statistic to compare size at maturity in Division 3NO.

	1992	1993
1993	-1.3660	
1994	-6.9244*	-3.8142*

* Z significative(P<0.01)

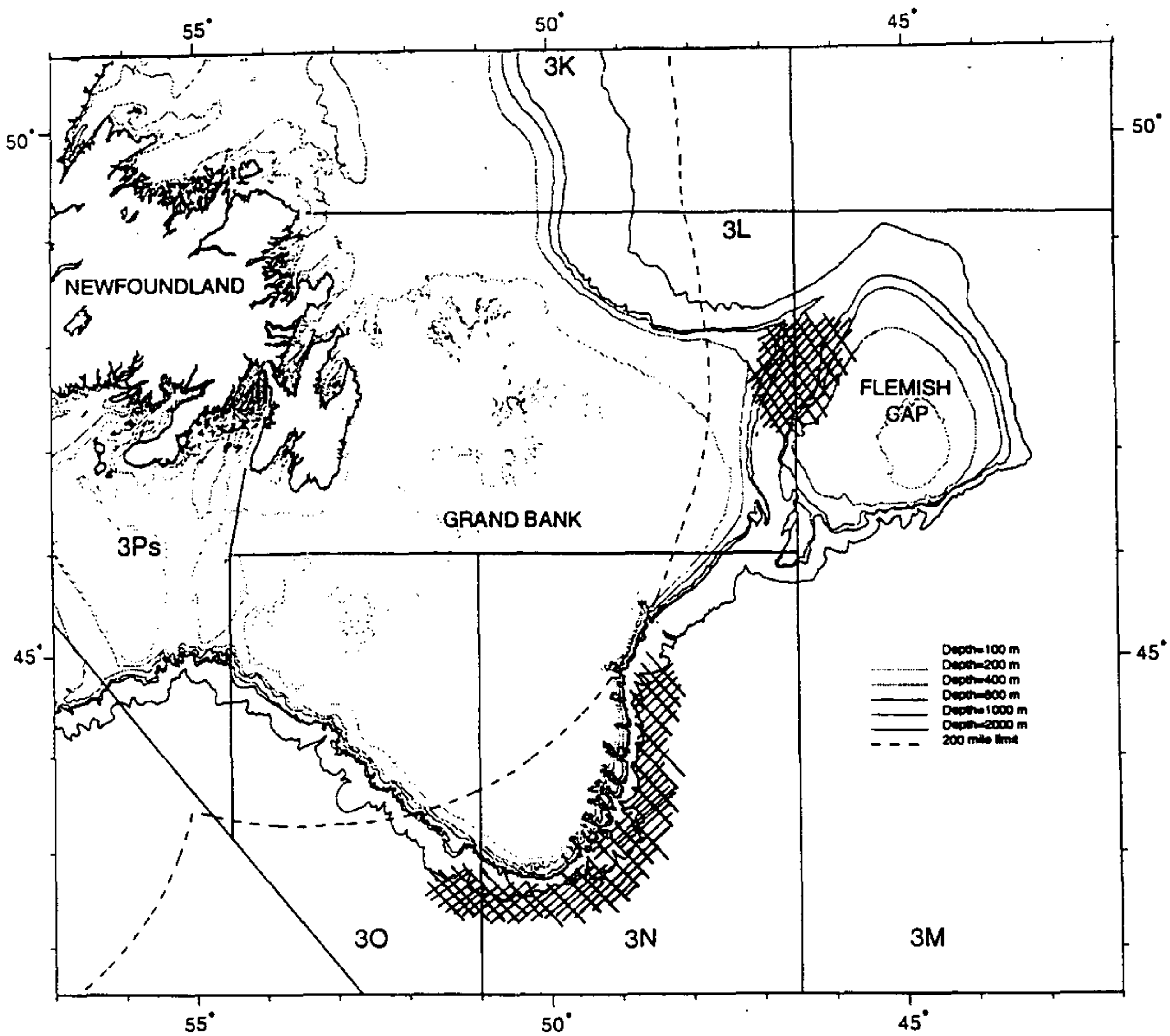

Figure 1. Sampling area

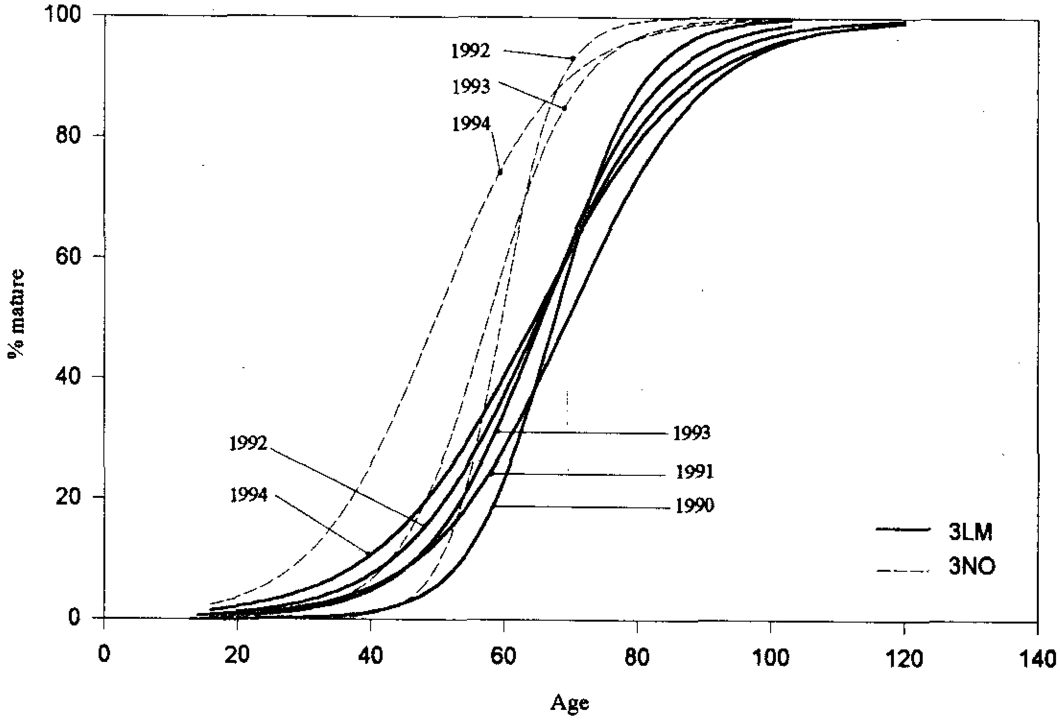

Figure 2.- Sexual maturity curves of female Greendland halibut from Divisions 3LM (1990-94) and 3NO (1992-94)