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Sexual Maturity and Spawning of the Greenland Halibut (*Reinhardtius hippoglossoides*) From Flemish Pass Area

by

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INTRODUCTION.

Greenland halibut is the major component of the Spanish deep water trawl fishery operating mainly along the continental slopes between 3L and 3M NAFO Divisions since 1990 (Figure 1).

Fishing activities of this fleet are restricted to depths between 800 and 1700 meters, a range of depths where the available information on the biology of this species is very scarce.

Greenland halibut is supposed to spawn mainly in the Davis Strait area (lat. 67º N) (SMIDT, 1969). Spawning seems also to occur to a lesser extent in the Gulf of St. Lawrence (TEMPLEM N 1973) and in West-Greenland (RIJET and BOJE, 1989). However most of the information available about the reproduction of this species refers to its shallower are of distribution.

In this paper we deal with the description of reproductive aspects o the Greenland halibut in the Flemish Pass area, based on data supplied by observers on board the Spanish commercial fleet. Its interests rely on the one hand in that they provide long lasting systematic sampling all year round and on the other hand, on their activity in deep waters (800-1700 meters) and areas from w ere there was no information available until now, so clarifying unknown aspects of the biology and dynamics of this species.

MATERIAL AND METHODS.

The data used here are supplied by observers on board Spanish commercial deep-water trawlers, and collected from May to Dece ber in 1990 and all the year in 1991. Depth ranges from 800 to 1700 meters and for sampling design and data processing has been divided into three strata: <= 900 m, 901-1100 m and >= 1100 m.

Length of fish is recorded as total length and the stage of maturity in females determined visually using a scale of four maturation stages:

1) IMMATURE. Ovary very small and pinkish, thin walled, eggs not visible to the naked eye.

& 2) MATURING. Eggs visible with the naked eye, eggs all opaque, ovarian wall thin.

3) SPAWNING. Eggs visible with the naked eye, some eggs opaque and others clear (hydrated) or all the eggs clear (hydrated)

4) SPENT. Ovary appears reddish, wall thickened, new eggs not visible to naked eye.

The proportion of spawning females (stage 3) is followed through the year in order to identify the pawning season.

Female maturity-at-length data from 1990-91 in Divisions 3L and 3M and depth strata are used to generate maturity curves and to determine the length of 50% maturity (M_{50}) by the "probit transformation" method (FISHER and YATES 1948), as applied in cod by FLEMING (1960) and in this species by BOWERING (1983). Fish are considered immature if they have ovaries in stage 1 and mature in either stages 2, 3 or 4. Goodness of fit is tested with the Chi-square statistic.

To analy e seasonal changes in the capturability that could be related with movements either in depth or migrations out of the fishing area, we used the catch rates standardized with a multiplicative model (VAZQUEZ, 1981).

RESULTS.

In the Flemish Pass area there is an increase in the size and proportion of females with depth in both Divisions 3L and 3M (Figure 2). The sex-ratios in the catch showed a clear dominance of females in the whole area during the secon half of 1991, and their proportion increased even more in the last part of the year (table 1).

Goodness of fit for maturity curves (figure 3) were significant in all the cases considered ($P<0.05$). Length of 50% maturity varied from 67.3 cm for 1990, combining data of 3L and 3M, to 73.2 cm for the deepest strata of Division 3M in 1990 (table 2). The range of size over which sexual maturity takes place is represented by the slopes and Y-intercepts of the computed lines. The result of the ANCOVA of the fitted lines (SOKAL and ROHLF, 1969) shows that there is no statistical difference either between slopes (m) or Y-intercepts at 5% significance level ($F=1.9$ and $F=0.8$ respectively; d.f.= 3, ∞). In consequence it can be assumed that the variability observed in M_{50} is not significant, and the differences found could be related with a higher frequency of big sizes in the deepest strata of Division 3M.

In both Divisions (3L and 3M) several of the biggest individuals appeared unexpectedly as immatures (Figure 3) in all depth strata. In the shallowest strata of 3M the proportion of mature females never reach the 50% level and consequently a maturity curve could not be fitted there.

The percentage of spawning females in 1991 is shown in table 3. The peak of spawning during the sampling period was found in July and August, with 20% of the mature fe ales in spawning stage (with hydrated eggs). It is also w rth noting the presence of a secondary peak in December (7%) and some spawning activity all the rest of the year.

The possibility exists as in other species, that the reproductive behaviour could affect fishing activities in some way. In figure 4 the trend of the standardized catch rates is represented. It can be seen that the maximum values are attained

in both Divisions 3L and 3M in winter, and a general decline in the catch rate coincides with the peak of spaw-ning. The values in Division 3L show slighter seasonal variations than Div. 3M .

DISCUSSION.

Spawning of Greenland halibut is considered to occur mainly in the deep warm water of Davis Strait (675 m) (SMIDT, 1969), from where both northern and southern ar as are colonized (TEMPLEMAN, 1973). Other spawning areas are reported in West-Greenland fjords (RIGET and BOJE, 1989) and in the Gulf of St. Lawrence (TEMPLEMAN, 1973). Adult mature fish are believed to undertake a migration northward to the main spawning area (BOWERING and BRODIE, 1991), while the smaller immature fish remain in southern areas (ZILANOV et al. 1976; BOWERING, 1977). The results of this paper show that spawning also takes place in the Flemish Pass area and this occurs mainly in summer although there is also significant spawning activity in December with 7% of the mature females, and slight reproductive activity during all the year. This asynchronous spawning behaviour in Greenland halibut was also found by FEDOROV (1971) in Barents Sea, where he indicates the existence of two peaks of spawning, one in winter and another secondary in May-June, with some spawning activity detectable all the year.

The length frequencies observed show an increase in size with depth, and the clear dominance of females in the deepest strata all the year. This segregation by depth is a usual feature in this species (ZILANOV et al. 1976; BOWERING 1982) and seems to be related mainly with size rather than with spawning activity, since the slopes of the maturity curves do not show significant differences by depth strata.

The maximum values of catch rates and of spawning do not coincide in time, which seems to indicate that the reproductive status of fish does not have a major influence on fishing efficiency, and it is possible that environmental factors could

have stronger effects, as already pointed out by some authors (CHUMAKOV and SA-VVATIMSKY 1990; ERNST 1984).

The range of sizes of the 50% of maturity (M_{50}) obtained for Flemish Pass area (67-73 cm) is similar to the one reported by Bowering (1983) for the northern areas (Subareas 0 and 2) and somewhat lower than the values obtained by him for the northwestern Newfoundland shelf (79.6 cm).

Some of the largest individuals sampled (above 80 cm) were unexpectedly found have to be immature, according to their size well above the M_{50} value. This fact seems to indicate the existence of processes of failure to mature, described by FE OROV (1971) as quite frequent in this species.

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TABLE 1.- Percentage of females in the catch in Divisions 3M and 3L.

MONTH	JUL	AUG	SEP	OCT	NOV	DEC	JAN
DIVISION							
3L	62.3	58 3	67.9	69.7	72.3	73.2	73.6
3M	66.5	66	70.5	73.4	74.6	72.7	-

TABLE 2.- Probit analyses of sexual maturity of the Greenland halibut in Divisions 3L and 3M in 1991, and combined 3LM in 1990. All Chi-square test indicate the acceptance of the fitted line to the observed data at the 5% significance level. (A=depth <= 900 m; B= depth 900-1100 m; C= depth >= 1100).

YEAR	1991			1990
DIVISION	3L		3M	3LM
DEPTH	A	B+C	B+C	A+B+C
Slope (m)	0.05	0.05	0.06	0.07
Y-intercept	1.59	1.53	0.62	0.96
M50	68.2	69.4	73.2	67.3
SE(M50)	0.41	0.1	0.17	0.26
SE(m)	3.7*10	2*10	5.1*10	3.1*10
N	16062	61729	123802	16925

M50 = Length of 50% maturity
SE(M50)= Standar error of M50
SE(m) = Standar error of the slope (m)
N = Number of females analysed

TABLE 3.- Monthly percentage of spawning females (with hidrated eggs) in the Flemish Pass during 1991.

MONTH	PERCENTAGE	NUMBER
Ja uary	0	423
February	2.8	776
March	0.8	1948
April	1.9	639
May	-	-
June	-	-
July	20	87
August	20.9	1106
September	7.3	1159
Octover	3.3	1353
November	1.6	2275
December	7.1	792

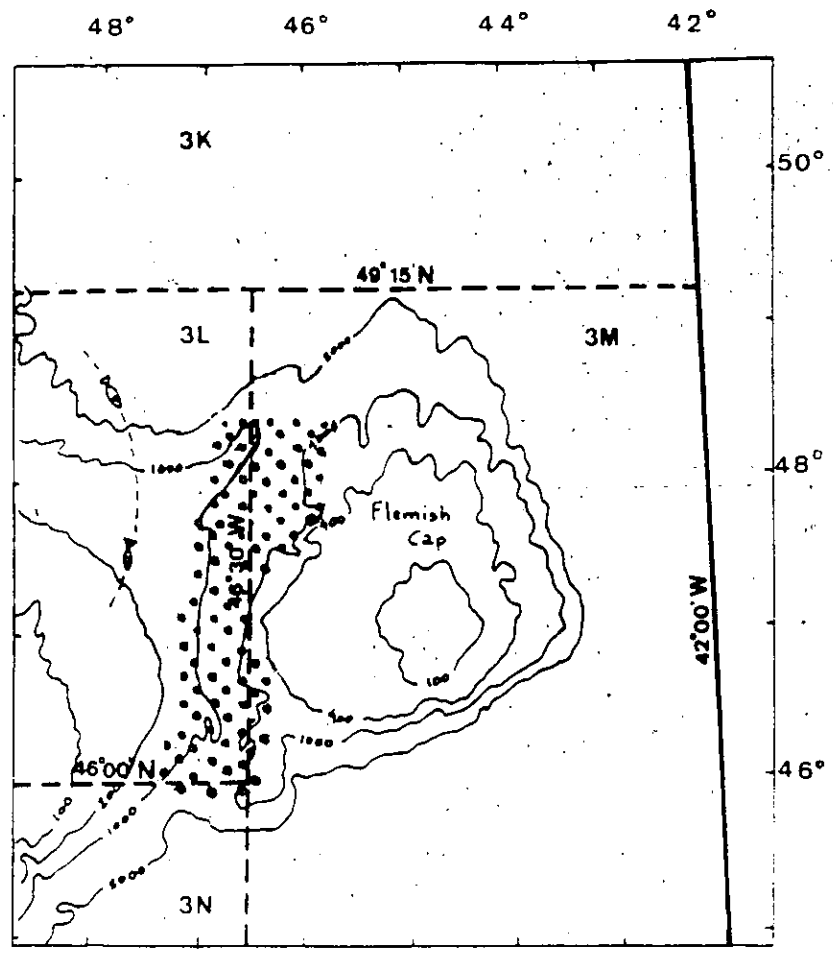


Fig. 1 - Fishing area in 1990 - 91. (Depth in meters).

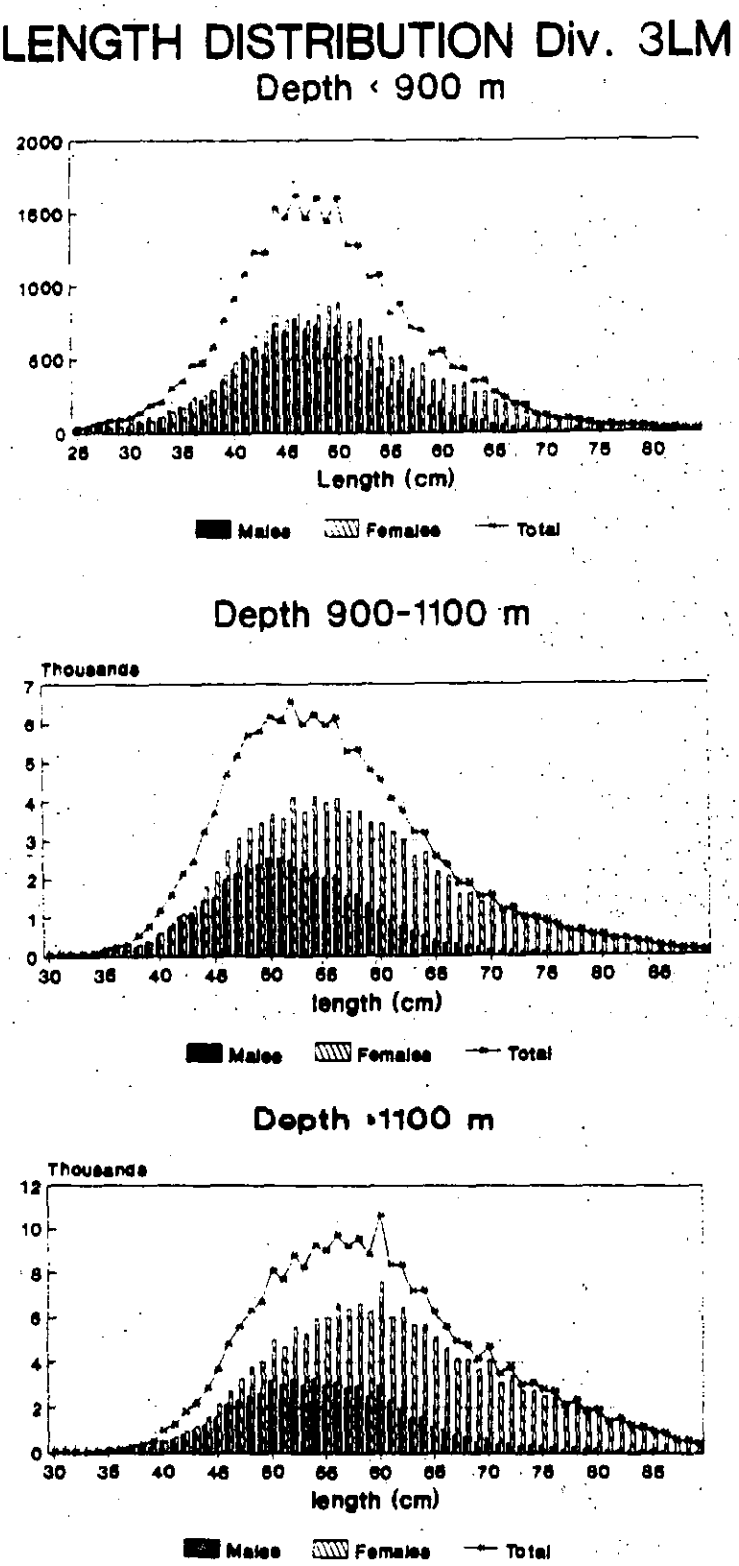
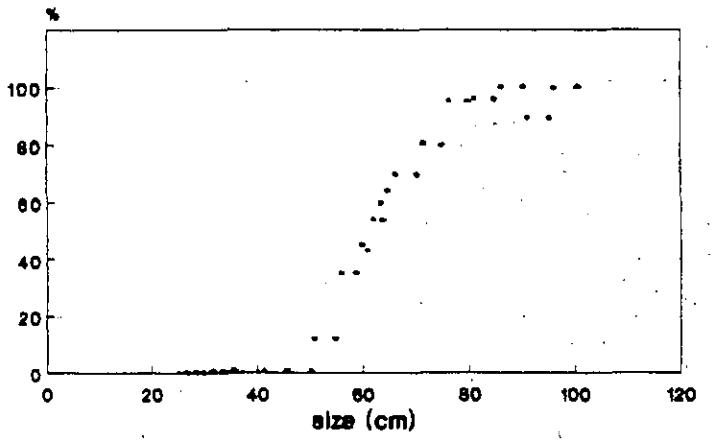
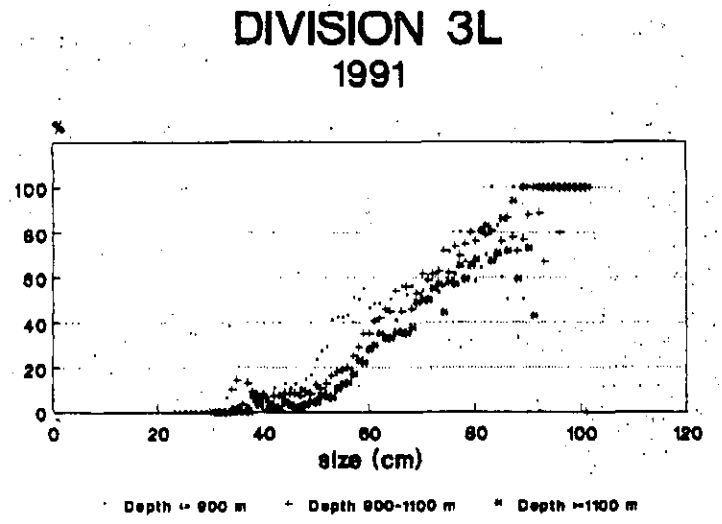


Fig. 2 - Lenght distributions of Greenland halibut by sexes and depth strata in 1990 - 91.





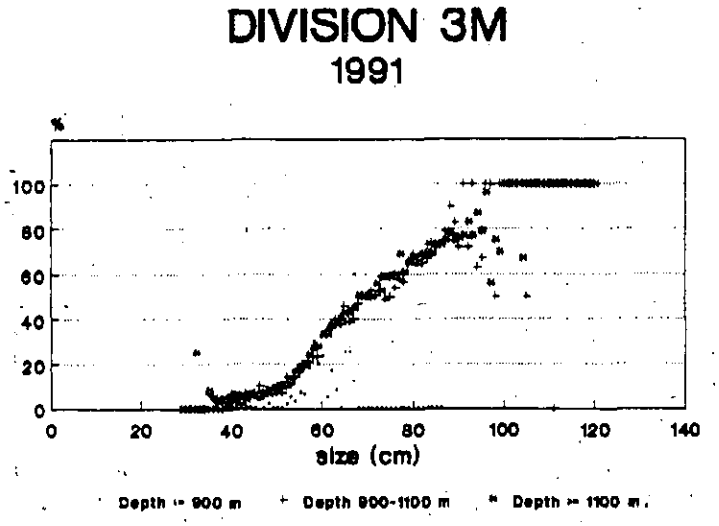
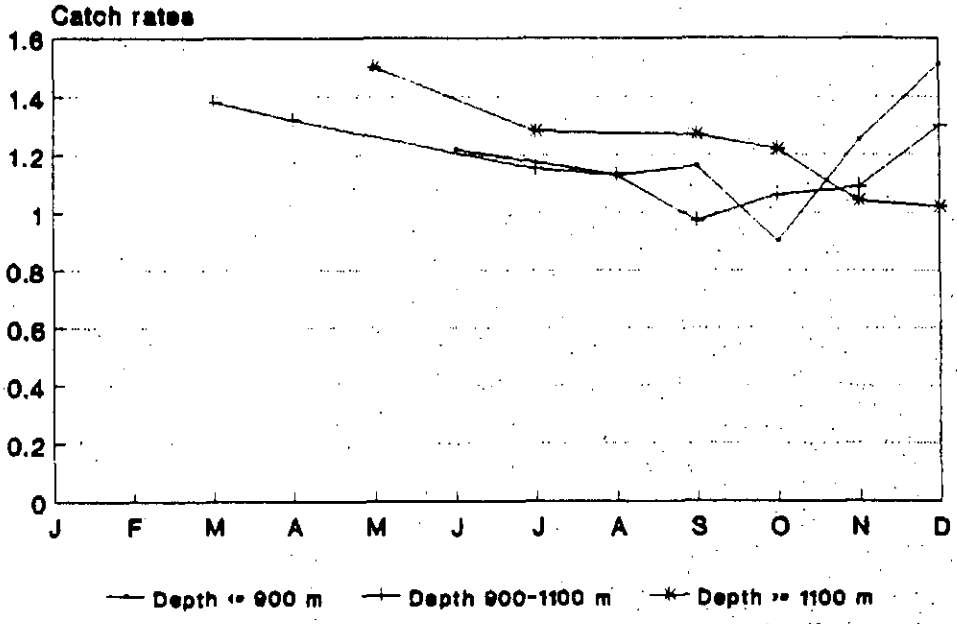


Fig. 3 - Sexual maturity ogives of female Greenland halibut from Divisions 3L and 3M in 1990-91, by depth strata.

DIVISION 3L



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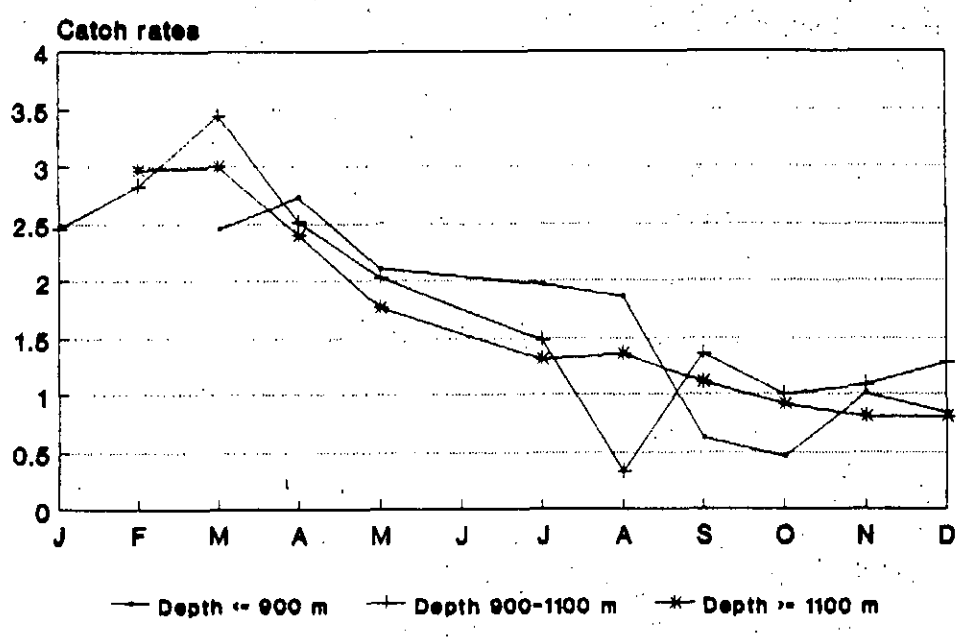

Fig. 4 - Annual evolution of the standardized catch rates in the Greenland halibut fishery in Div. 3L and 3M by depth strata.