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Length at First Maturity of Roughhead Grenadier, *Macrourus berglax*, in NAFO Divisions 3MNL

by

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Abstract

This paper gives an estimation of the length at first maturity for roughhead grenadier in Newfoundland waters (NAFO divisions 3M, 3N, 3L) using histological analysis of ovaries collected during experimental and commercial cruises carried out in 1995 and 1996.

Using histological techniques the length at first maturity (L50) for roughhead grenadier females was 66.7 cm, corresponding approximately with 14.8 years (A50). This results is very similar to the findings by Eliassen and Petersen (1985), who reported a L50 of 65 cm and a A50 of 15 years for the same species in the NE Atlantic using macroscopic techniques.

Introduction

Roughhead grenadier has became an important commercial resource in north Atlantic waters, although it does not historically constitute a target fishery and generally is only a by-catch in other traditional fisheries in the area. The directed fishery is carried out by Russian and Norwegian fleets in the Barents Sea (Eliassen, 1983) and by some Spanish and Portuguese vessels in the NAFO regulatory area (Paz & Iglesias, 1994).

The assessment of this fish resource needs a deep evaluation of several population parameters. Among them, the reproductive parameters are of primary importance to measure the reproductive potential of the population and to properly understand its resilience to exploitation and the significance of changes in the spawning biomass.

Several works reported studies on the reproductive biology of this species. The roughhead grenadier (*Macrourus berglax*) shows a "determinate fecundity" (Murua & Motos, MS1996). The species is a "group synchronous" (Eliassen & Petersen, 1985) winter-spring spawner species (Geistdoeffer, 1979; Eliassen & Petersen, 1985; Savvatimsky 1984 and 1989; Murua & Motos, MS1996). The maturation of the oocytes seems to take more than one year (Eliassen & Petersen, 1985). These traits are typical of organism inhabiting extreme environments such as deep-sea and the polar regions species: *Hippoglossoides platessoides* (Zamarro 1992a, Milinsky 1994); *Gadus morhua* (Kjesbu *et al.*, 1991); *Reinhardtius hippoglossoides* (Junquera & Saborido-Rey, 1995).

When assesing the reproductive parameters of a fish population, length/age at first maturity is one of the key tasks. The age of first maturity for roughhead grenadier was reported by Eliassen & Petersen (1985). This author used macroscopic techniques to report an age of first maturity of 15 years (65 cm) for roughhead grenadiers in the Northeast Atlantic. However, the use of histological techniques to estimate the length or age at maturity using histological techniques has proved more precise than the traditional macroscopic ones, and have became of widespread use in the last few years (West, 1990). Histological techniques allow for checking the maturation stage of the ovary at a microscopic level. The cortical alveoli stage is then used as the indication of the onset of oocyte development for the next breeding season (Wallace & Selman, 1981; Zamarro *et al.*, 1993). The cortical alveoli are the first structures to appear during the phase of (secondary) oocyte growth, and thus are the first sign of the start of the ovary maturation before the imminent beginning of the vitellogenesis (Wallace and Selman, *op.cit.*).

Material and methods

A total of 297 roughhead grenadier ovaries were sampled during three different cruises carried out in NAFO regulatory area 3M, 3N and 3L during 1995 and 1996 (Table 1).

All individual sampled were selected for reproductive biology studies. 20 ovaries were collected by a commercial trawler vessel aimed to study trawl selectivity and 100 ovaries were collected during the Flemish cap groundfish cruise carried out in February 1995 and July 1995, respectively. In addition, 177 ovaries were sampled during a European long-line survey carried out in NAFO Divisions 3MNL during April-May 1996.

All individuals were measured (total length) to the lowest 0.1 cm and weighed to the nearest gram. Only pre-anal length was recorded in the surveys carried out in 1995. Total length for these individuals was calculated by means of a pre-anal length (Lp)-total length (Lt) relationship as recorded in the European long-line survey carried out in April-May 1996 (Fig. 1).

Females were opened by the belly and the gonads were extracted and preserved in a standard solution of 4% buffered formaldehyde (Hunter, 1985). At the laboratory, the gonads were weighed, had a piece removed and were histologically processed. The pieces were dehydrated and then embedded in Historesine. Subsequently, histological sections were cut at 5 µm and stained with H&E.

Different stages were identified following the classification of West (1990), Wallace and Selman (1981) and Murua & Motos (MS 1996). Immature females were identified when all the oocytes present in the ovary were in the primary growth stage; on the contrary the presence of at least one of following oocyte development categories in the ovary served to classify a female as mature: cortical alveoli (CA), vitellogenesis, postovulatory follicles (POF) or atretic oocytes. Each ovary was then classified histologically according to the more advanced oocyte stage present in the ovary. The presence/absence of all the oocyte and postovulatory follicle stages were also recorded.

The proportion of mature females by length was fitted to a logistic equation as described by Ashton (1972) and applied to another species (Ni and Sandeman, 1984; Haldorson and Love, 1991; Saborido and Junquera, 1995):

$$\hat{P} = \frac{e^{\alpha+\beta L}}{1+e^{\alpha+\beta L}} \qquad \textit{eq. 1}$$

and the logit transformation:

$$\ln\frac{\hat{P}}{1-\hat{P}} = \alpha+\beta L \qquad \textit{eq. 2}$$

where

$\hat{P}$ are the predicted mature proportion
α and β are the coefficients of the logistic equation
L is the length

The statistical package STATGRAPHICS 1.4 was used to fit the relationship to the data and consequently to estimate the coefficients and and to calculate the predicted values. The length at first maturity was obtained as the ratio of the coefficients (- /), by substituting $\hat{P}$ by 0.5 in equation (2).

Results and Discussion

Table 2 shows the number of mature and immature females by length categories. 126 females of the 297 sampled were immatures (42.4%) and 171 were matures (57.6%).

The number of females in the different development stages, i.e. cortical alveoli, vitellogenesis, mature (oil globule fusion and migration), and postovulatory follicle, are presented in table 3.

Most of the adults females were in maturing stages, 67% of them showed CA stage oocytes, which indicate the onset of oocyte development towards maturation. The mode of the advanced oocyte clutch appear in early vitellogenesis stages in near 24% of the ovaries and in late vitellogenesis in near 9% of the ovaries, indicating that these oocytes will be spawned later during the upcoming spawning season. Some ovaries were in post-spawning condition with atretic stage oocytes being prevalent. Only CA stages remained in those atretic, post-spawnig ovaries.

All the ovaries presenting POFs also showed advanced vitellogenic stage oocytes (VIT 2 or 3, Murua & Motos, MS 1996).

Length at first maturity

The maturity curve by length obtained using the logit method is presented in Fig. 2 and the parameters of the model in table 4. The proportions of mature female by length presented a good fit to the logistic model (R^2 = 89%). The length at first maturity (L50) for roughhead grenadier females was 66.7 cm (L50), this length corresponding approximately with 14.8 years (A50) according with the length-age relationship proposed by Savvatimsky in 1984 for the Labrador Sea. This result is very similar to the findings by Eliassen and Petersen (1985), who reported a L50 of 65 cm and a A50 of 15 years for the same species in the NE Atlantic.

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Table 1.- Number of gonads collected during the period of study.

YEAR	MONTH	GEAR	AREA (NAFO DIVISIONS)			TOTAL
			3M	3N	3L	
1995	FEBRUARY	TRAWLING	0	0	20	20
1995	JULY	TRAWLING	100	0	0	100
1996	APRIL-MAY	LONG-LINE	98	54	25	177
TOTAL			198	54	45	297

Table 2.- Numbers of mature, immature and total females of roughhead grenadier sampled by length intervals.

LENGTH (cm)	INMATURE	MATURE	TOTAL
36-39	2		2
39-42	2		2
42-45	1		1
45-48	7		7
48-51	12		12
51-54	23		23
54-57	25		25
57-60	25	1	26
60-63	6	3	9
63-66	7	1	8
66-69	9	15	24
69-72	4	24	28
72-75	1	21	22
75-78	1	25	26
78-81	1	23	24
81-84		23	23
84-87		21	21
87-90		5	5
>90		9	9
TOTAL	126	171	297

Table 3.- Number of roughhead grenadier mature female oocytes in the cortical alveoli stage, vitellogenic stages (1,2,3) and postovulatory follicles(in brackets the vitellogenic state of the ovary that shows a postovulatory follicle).

LENGTH (cm)	C.A.	VIT 1	VIT 2	VIT 3	M.N.	POF	TOTAL
36-39							2
39-42							2
42-45							1
45-48							7
48-51							12
51-54							23
54-57							25
57-60	1						26
60-63	2	1					9
63-66		1					8
66-69	12		1	1	1	1 (3)	24
69-72	20		2	1		1 (3)	28
72-75	15	4		1	1	1 (3)	22
75-78	21	3	2				26
78-81	16	3	2	1	1		24
81-84	12	6	3	3		3(2,3,3)	23
84-87	9	7	1	3		3 (3)	21
87-90	3	1		1		1 (3)	5
>90	4	4		1			9
TOTAL							297
MAT. TOTAL	115	30	11	12	3		171

Table 4.- Logit parameters of the roughhead grenadier female maturity curve (L_{50} = length at first maturity).

PARAMETERS	α	β
Estimate	-21.255	0.319
Standard error	3.229	0.047
T (295)	-6.58	6.84
p level	0.0006	0.0005
Number of females = 297		
L50 ($-\alpha/\beta$) = 66.7 cm		
R2 squared = 89%		

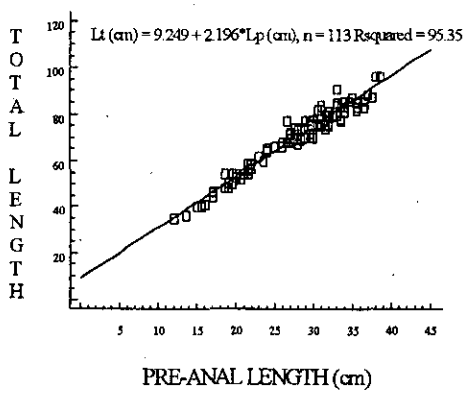

Figure 1: Linear regression fit between pre-anal length (cm) and total length (cm) for roughhead grenadier individuals collected during the EU long-line survey carried out in April-May 1996 in NAFO Divisions 3MLN.

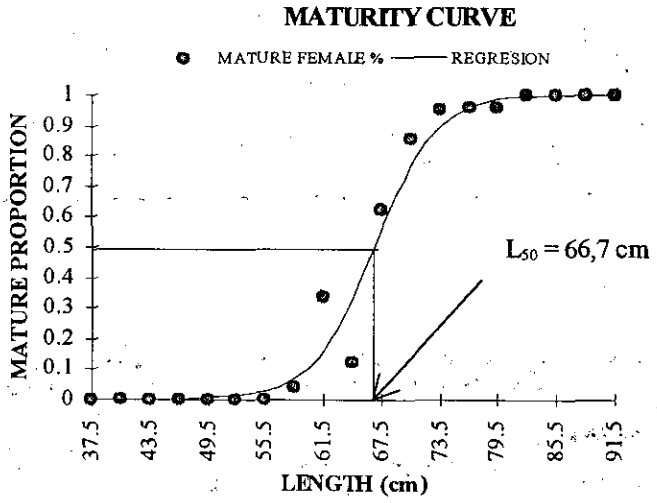

Figure 2 : Proportion of mature females by length and logit regresion fitting curve.