

Length and Age of First Maturation of Flemish Cap Cod (*Gadus morhua*) in 1993 with an Histological Study

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Abstract

Ovaries of cod (*Gadus morhua*) caught on the Flemish Cap in July 1993 were analyzed histologically to calculate spawning frequency in both past and future spawning seasons. The percentage of females ripening for the first time was also studied. The cod length ranged from 31 to 88 cm and the ages from 2 to 8 years. The occurrences of cortical alveoli in the ovaries was used as a criterion to indicate future spawners, and the postovulatory follicles as a criterion to indicate females which had spawned at least once. Ogives prepared for each criterion showed the 50% maturation at 50 cm length and 4 years old for future spawners, and the 50% maturation at 64 cm length and 5 years old was calculated for females which had spawned at least once.

Key words: Cod, Flemish Cap, histology, spawning

Introduction

The maturity stage of cod (*Gadus morhua*) is very easy to identify in females during most of the annual reproductive cycle using the macroscopic features of the ovary (Pitt, 1966; Morrison, 1990), but it is very difficult as ripening begins. The previously used Gonosomatic Index (Zamarro *et al.*, MS 1993) was not used in this study because it does not allow the correct identification of mature stages in all females.

It is not possible by macroscopic analysis to predict when females will mature particularly when ovaries are sampled outside the ripening season. This is the problem with cod ovaries sampled in the July survey conducted by the European Union on Flemish Cap. However, we propose this can be overcome by histological analysis. In fact, there are histological methods to classify maturity stages: Kjesbu (1991) used oocytes size, and Morrison (1990) and Zamarro *et al.* (MS 1993) used the presence of different kinds of oocytes in histological preparations. In our study oocytes in the circumnuclear ring, cortical alveoli and vitellogenesis stages, were used for the identification of females at the beginning of ripening season and the postovulatory follicles were used to identify past spawners (Zamarro *et al.*, MS 1993). Previous results indicated that less than two months elapses between the end of spawning and the beginning of the development of cortical alveoli as an indicator of renewed ripening. Also, there is a period of more than three months between the end of spawning and

the vitellogenesis stage. Post-ovulatory follicles last a long time in the ovary, and their identification is possible seven months after spawning. Thus, it is possible to make the maturation ogive three months after spawning.

In this study the method described by Zamarro *et al.* (MS 1993) was followed to identify the maturation stage at the beginning of the ripening season, and to calculate spawning frequency in both past and future spawning seasons.

Materials and Methods

Ovaries from 221 cod fish were taken during the summer survey on the Flemish Cap in July 1993 on board R/V *Cornide de Saavedra* (Vazquez, MS 1994). Ovaries were fixed in 10% buffered formaldehyde (Hunter, 1985), the size and weight of each fish was recorded, and the otoliths were aged.

The ovaries were weighed in the laboratory. Sections 0.5 cm thick were cut from them and embedded in paraffin block for standard histological sectioning. The 5µ thick sections were stained with Harris Hematoxyline and eosine floxina B and studied under the light microscope.

The Kjesbu and Kryvi (1989) and Morrison (1990) criteria were used to differentiate maturity stages. The stages considered were:

- Circumnuclear ring oocytes: this stage characterizes immature females if there are no later stages present.

- Cortical alveoli oocytes: this stage is present in females which will spawn in the following year.
- Vitellogenesis: this is an intermediate stage, between cortical alveoli and postovulatory follicles.
- Postovulatory follicles: these follicles are present only in females which have spawned in the previous season.

Results and Discussion

All ovaries examined had oocytes in the circumnuclear ring stage. These oocytes will mature in the next or some later spawning season. However, based on the presence of this kind of oocytes in ovaries, they can not be used as an indicator of new spawners because according to their size these cod must be immature. The presence of these oocytes also indicates that this stage lasts longer than one year (Zamarro *et al.*, MS 1993).

Tables 1 and 2 show the number and percentage of ovaries with cortical alveoli (CORT), vitellogenesis (VIT) and postovulatory follicles (POF) in different size and age classes, respectively. In the interpretation of the stages, it is noted that ovaries without cortical alveoli, vitellogenesis and postovulatory follicles indicate that they come from immature females. Ovaries with cortical alveoli but without postovulatory follicles indicate they belong to fish which would spawn during the next season (none were found in this study). The Tables 1 and 2 show the percentage of females with vitellogenesis stage increased with size and age. It was also observed that the youngest mature females did not begin vitellogenesis in July; less than 30% of these females showed vitellogenesis. This indicated that, the period between the end of spawning and the beginning of vitellogenesis is shorter in larger females than in smaller ones.

The proportion of females with postovulatory follicles increased with size, and it reached 100% at the size when all females had presumably spawned in the previous spawning season. Accordingly, the maturation ogive had to be constructed using the percentage of ovaries with postovulatory follicles.

Figure 1 shows two maturation ogives by length. One was made with mature females with postovulatory follicles, corresponding to 1993 spawners. The other was made using the cortical alveoli as a criterion, corresponding to 1994 spawners. The ogive using postovulatory follicles shows that length at 50% maturation was at 64 cm. The other ogive using cortical alveoli shows the length at 50% next maturation was at 50 cm. Both lengths calculated here indicated out-of-season references to maturation. The 50% maturation length in 1993 would have been in fact shorter than 64 cm because fish would have grown after spawning until July, when the samples were taken. Similarly, the 50% maturation length in 1994 should be greater than 50 cm.

Figure 2 shows the two maturation ogives using the corresponding age. The age at 50% maturity was 5 years for 1993 spawners, and 4 years for fish which will spawn in the following year.

The maturation ogives (Fig. 1 and 2) using the cortical alveoli stage to identify mature females gave similar results to those of Zamarro *et al.* (MS 1993). It could thus be concluded that females develop cortical alveoli between June and July, indicating that these females will spawn in the next year.

In Div. 2J+3KL, an area close to the Flemish Cap, a 50% maturation length of 50 cm of cod was observed in 1990, with a decrease in recent years due either to overfishing or to environmental factors (Xu *et*

TABLE 1. Samples analyzed by size of July 1993 giving number of ovaries, number and percentage of ovaries with oocytes in cortical alveoli stage (CORT), incidents of vitellogenesis (VIT) and postovulatory follicles (POF).

Size	Number	CORT	%CORT	VIT	%VIT	POF	%POF
28–34	3	0	0	0	0	0	0
34–40	17	5	29.41	0	0	1	5.88
40–46	62	25	40.32	1	1.61	2	3.23
46–52	55	24	43.64	4	7.27	8	14.55
52–58	10	7	70.00	1	10.00	1	10.00
58–64	27	25	92.59	9	33.33	18	66.67
64–70	27	25	92.59	9	33.33	22	81.48
70–76	10	9	90.00	4	40.00	5	50.00
76–82	6	6	100.00	2	33.33	6	100.00
82–88	3	3	100.00	2	66.67	3	100.00
+88	1	1	100.00	0	0	1	100.00

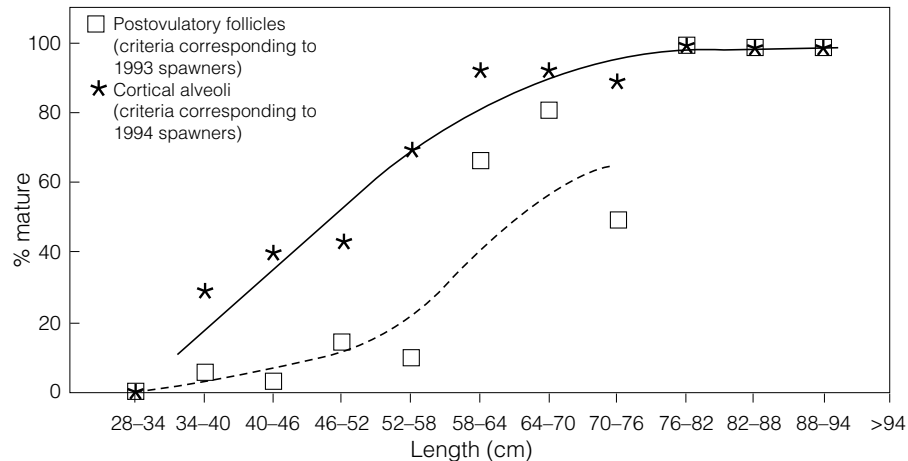


Fig. 1. Percentage-by-length of mature females of Flemish Cap cod in July 1993, based on two criteria of histological observations of ovaries: 1) mature females exhibiting postovulatory follicles corresponding to 1993 spawners. 2) females showing cortical alveoli corresponding to 1994 spawners.

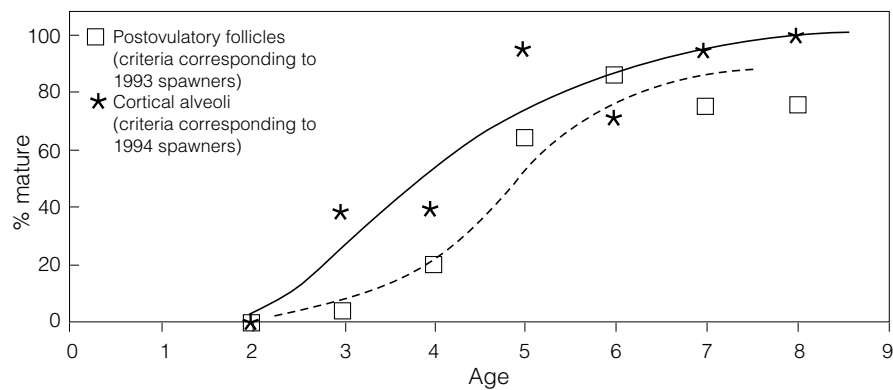


Fig. 2. Percentage-by-age of mature females of Flemish Cap cod in July 1993, based on two criteria of histological observations of ovaries: 1) mature females exhibiting postovulatory follicles corresponding to 1993 spawners. 2) females showing cortical alveoli corresponding to 1994 spawners.

al., MS 1991). In this area, the 50% maturation by age and length showed a North-South cline with averages of 5 years and 50 cm, respectively (Baird *et al.*, MS 1986).

In our study, the difference between the ages of 50% maturation based on cortical alveoli and postovulatory follicles was 1 year. Zamarro *et al.* (MS 1993) show a difference of 1.8 years between ages of 50% maturation. This one year difference is proposed to be due to the one year delay between the cortical alveoli stage and the postovulatory follicles. The balance of the difference of 0.8 years, however, may be related to differences between cohorts in the age at 50% maturation and to errors of the method. In the present study, we obtained a 1.0 year

difference between 1993 and 1994 spawners, which is closer to an expected stable situation than the Zamarro *et al.* (MS 1993) study.

With respect to future spawners, Zamarro *et al.* (MS 1993) obtained an age of 3.8 years for those of 1993, while our results indicated the 1993 spawners were 5 years old. Since these two age references belong to the spawning stock of the same period, that of 1993; the 1.2 years difference may be attributed to the one year delay between sampling, and the remaining 0.2 years difference due to an inherent error in the method. However, we judge the differences to be low, and consequently propose that the methods used here are valid for determining maturation patterns of the cod.

TABLE 2. Samples analyzed by age of July 1993 giving number of ovaries, number and percentage of ovaries with oocytes in cortical alveoli stage (CORT), incidents of vitellogenesis (VIT) and postovulatory follicles (POF).

Age	Number	CORT	%CORT	VIT	%VIT	POF	%POF
0	26	6	23.07	2	25.00	4	15.38
2	3	0	0	0	0	0	0
3	121	47	38.84	3	2.50	5	4.13
4	15	6	40.00	3	20.00	3	20.00
5	45	43	95.55	15	32.61	29	64.44
6	7	5	71.43	1	14.28	6	85.71
7	20	19	95.00	8	40.00	15	75.00
8	4	4	100.00	4	100.00	3	75.00

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