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Otolith age validation in cod from the northeastern Gulf of St. Lawrence

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INTRODUCTION

Recent workers (Saetersdal, 1953; Kohler, 1964; May, 1967) have emphasized and reiterated Dannevig's (1933) observation that a critical approach is essential to age determination procedures. Examination of skeletal structures for estimations of age involves some interpretation as well as simple counting of annual growth markings. Hence validation studies assume importance in determining the correctness of these elucidations.

MATERIALS AND METHODS

For the purposes of this study, offshore research vessel material was combined with commercial and research samples collected inshore. Offshore material was collected by Canadian research vessels using No. 36 or 41-5 otter trawls with small meshed codends. Usually, but not always, the codend was lined or covered with fine mesh nylon netting. Inshore samples were taken by handline, linetrawl or longline and usually in shallow water close to shore.

Collections were made in every month of the year except February, April and May and consisted of otoliths and length frequency data. Otolith samples were either random, random plus "categories" or "stratified" sub-samples of the measured fish; all measurements were of fork length, taken from the catch at random. Details of the length and otolith samples used in this study are given in Wiles, (MS, 1967).

Age determinations were from sacculus otoliths read according to the method given in the summary by Keir (MS, 1960). The type of edge deposit (opaque or hyaline) was recorded for each otolith at the time of the age reading. Age and edge data for all years were combined by month. Since they are broader than the hyaline zones, the opaque zones are thought to represent the period of greatest growth (Fleming, 1960). Hyaline zones begin to form when otolith (and hence bodily) growth slows down. Since they are more distinct then opaque zones they were used for age determinations

An empirical assessment of the age reading technique can be made by observing seasonal changes in the otolith edge and by comparing mean lengths of otolith ages so derived with modes in the length frequency distribution. Observations on both these methods are given below.

RESULTS

Otolith edges

Fig. 1A shows the occurrence of opaque edge in the otoliths of cod from the northeastern Gulf of St. Lawrence during nine months of the year. Opaque edges were present at least as early as March, but only in younger fish aged 3-7 years. In June and July the percentage of fish with opaque edges was still low, and mostly confined to 4-7 year olds. By September, about 40% of fish exhibited opaque edges, this appearance being present in all but the very old fish, and predominating only from August through November. The shape of the curve for opaque edges in Fig. 1A clearly demonstrates that only one opaque zone is formed each year. However, beginning in September some fish showed a narrow hyaline zone at the otolith edge which increased in thickness and became more common in later months, being particularly well developed from late October to December (Fig. 1). This zone was regarded as the next annual hyaline zone and was omitted from age estimations of fish collected before January 1. This is standard procedure in the St. John's Biological Station and prevents an error of one year being made in readings of fall and early winter samples. The hyaline edge was also predominant from January to July, when it was counted for age determinations.

The otoliths of most very old fish exhibited no recognizable opaque edges at any time of the year. A similar observation was made for Labrador cod by May (1967) who attributed this apparent lack to an inability to see extremely thin opaque zones which are masked by the broad, neighbouring hyaline zones. May's interpretation seems to be equally applicable to otoliths from the northeastern Gulf of St. Lawrence.

The opaque zone appeared earlier in the year in younger fish that it did in older ones, an observation also made by Williamson (MS, 1965) for Grand Bank cod and May (1967) for Labrador cod. The occurrence of opaque edges in fish of different ages is shown in Fig. 1B, for August, when the development of the opaque zone was almost at a maximum. It is clearly shown that the occurrence of opaque edge ranged from 90% at age 6 to about 30% at age 8 and less than 10% at age 14.

LENGTH FREQUENCIES AND MEAN LENGTHS FROM OTOLITHS

In Table 1 are given the modes of length frequencies of catches as taken by line gears and otter trawl during 1947-66, together with mean lengths of strong age classes from the corresponding age distributions, as calculated from age length keys based on otolith ages. These data show that there was good agreement between most modes in length compositions and the corresponding calculated mean length of strongly represented ages. Conformity was best for younger fish but in several samples a high degree of consistency was evident even for fish aged 10-12 years. It should be stressed that the approach to age validation used here is not truly an application of Petersen's method, which utilizes the recognition of separate modes of successive ages. In this study only dominant ages were compared with discernible modes in catch length compositions. This method is open to the criticism that the positions of the dominant ages within the length frequency distribution cannot be observed directly; they are simply assumed to be represented by recognizable modes. However, the substantial agreement obtained by this approach indicates that the method is reliable, at least for the series of data considered here.

DISCUSSION

The study of seasonal changes in otolith edges shows that one opaque and one hyaline zone are formed each year. Hyaline zones appeared first in September and persisted until July when they were almost completely replaced by a broader opaque zone. An opaque zone was present in varying degrees of development from March to November. Thus, there was appreciable overlap in the time of formation of the two types of edge, caused mainly by the early

(March) appearance of opaque edges in young fish, and its persistence in some individuals of all but the oldest ages even into early December. These changes indicate that the growing season in the Northeastern Gulf is four to four and a half months compared to about three months in Labrador as indicated by May's (1967) data and five months or more on the Grand Banks (Williamson, MS 1965). In this connection it is interesting to note that growth of cod in Divisions 4R and 4S (Wiles, MS 1967) is greater than that of Labrador cod but less than that of stocks on the Grand Banks (see also May et al (1965). Hence, observations on the seasonal changes in otolith edges of cod from the northeastern Gulf are consistent with conclusions derived from growth studies.

In the general Newfoundland area, "checks" or false (weak) rings are commonly found in otoliths. Checks were often seen in the present study, mostly in the first three years of growth but particularly in the second year, which often exhibited a bright, many banded hyaline zone. Such checks sometimes confused an age reading, but since they usually conformed to a distinctive pattern, they were early recognized as false rings and were not counted for ageing purposes. They usually formed "double", incomplete or weakly developed zones which did not fit into the pattern of decreasing opaque zone width which was related to increasing age. In fact, sometimes a check was recognized by its anomalous position or unusual spacing, rather than its appearance.

Modes in length compositions of catches were compared with age distributions based on otolith ages, but only dominant ages were considered. Poorly represented ages did not generally produce recognizable modes, the exceptions being the very youngest fish (1-3 year olds). Therefore the method of comparison used was an indirect deductive one where no attempt was made to prove that a particular mode was formed by fish of a particular age. Reliance was placed on finding good agreement between modal values and mean lengths calculated from otolith ages and adjusted by age length keys. The generally high degree of correlation found between modes and mean lengths is a good indication of the validity of the otolith ages, particularly since a reasonable number of samples were available for analysis.

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Table I. Modes in length frequencies of catches compared with mean lengths of dominant ages in corresponding age frequencies.

Sample Year	Gear	Age	Mean Length	Mode	Age	Mean Length	Mode	Age	Mean Length	Mode	Age	Mean Length	Mode
1947	Lines	4	47	49	5	52	55	10	65	73			
"	OT	3	34	34	6	54	52	12	78	58			
1948	"	4	43	43	7	59	61	10	67	70			
1950	"	2	26	25	4	45	43	8	65	67			
1953	Lines	7	58	61									
"	"	6	52	61	8-9	68	70	10-12	73	76			
1955	"	6	62	63	7	68	72						
1957	OT	2	23	25	5	51	52						
1961	"	4	41	43	7	63	61						
"	"	4-5	48	49	6	58	58						
1962	"	6-7	55	54									
"	"	1	15	13	5	49	49	6-7	58	59			
"	"	7	55	59									
1963	Lines	7	57	58	9	64	64						
1964	"	8	58	55	9	62	61						
"	"	7	58	61	10	66	67						
1965	OT	3-4	37	37	5	48	49	7	54	55			
"	"	2	23	25	3	34	34	4	40	43	6	51	52
1966	"	1	16	16	3	32	37	4	45	43	5	50	52
"	"	2	27	25	3	38	40	5	53	58			
"	Lines	11	79	73	12	82	82						
"	"	8	61	61	10	75	76	12	82	82			
"	"	8	66	61	9	73	70	10	75	79			

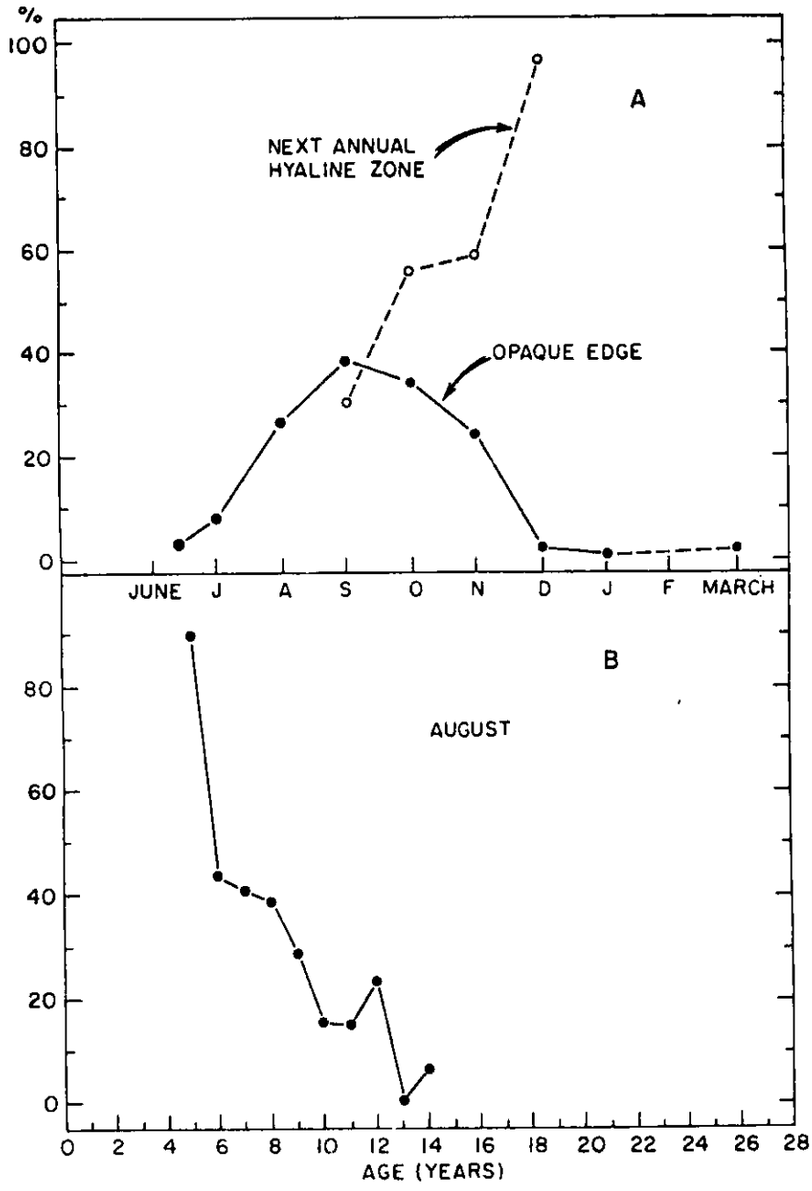

Fig. 1 A. Monthly incidence of opaque edge on otoliths of cod from the northeastern Gulf of St. Lawrence.

B. Incidence of opaque edge in cod of different ages in August.