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Quality of Newfoundland Region cod age determination

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Abstract

An outline of methods used to assess precision of aging and records of precision from 1978 to 1997 are presented. The result of a validation exercise involving early otolith collections (from 1978 to 1982) read by a current (1998) aging workgroup is documented. The aim of this exercise is to keep individuals interpreting ages of cod otolith samples in the Newfoundland Region at an 80% or greater agreement level with modal ages (Batten and Wells, 1979.). The results of otolith exchanges generally have exceeded requirements (Geddes, 1993.). The composition of the aging workgroup has changed over the years but agreement to the mode has been consistent.

Résumé

Un aperçu des méthodes utilisées pour évaluer la précision de la détermination de l'âge et les enregistrements de la précision de 1978 à 1997 est présenté. On y trouve les résultats d'une validation portant sur des collections antérieures d'otolithes (1978 à 1982) dont la lecture a été faite par un groupe de lecteurs actuel (1998). Cet exercice avait pour but d'obtenir que ceux qui interprètent les âges des otolithes de morue de la Région de Terre-Neuve obtiennent des résultats qui soient en accord à 80%, ou plus, avec l'âge modal (Batten et Wells, 1979). Les résultats des échanges d'otolithes ont généralement dépassé les exigences (Geddes, 1993). La composition du groupe de détermination des âges a changé au cours des ans mais la concordance avec le mode s'est maintenue.

Introduction

In July 1978 a cod otolith exchange program was initiated. The aim of this program was to keep individuals interpreting ages of cod otolith samples in the Newfoundland Region at an 80% or greater agreement level with the mode (Batten and Wells, 1979.). The modal age is determined from the ages estimated by the number of experienced readers comprising the cod aging workgroup over time. This mode is used as a measure of acceptability for new age readers.

The results of a current cod otolith exchange (No.65, 3Ps) and records from exchanges and readers since 1978 are tabled in this document. In addition five early exchanges (Table 9.) were reread by the current aging workgroup and the results of these exchanges and comparison to previous aging is presented. This comparison is made in order to validate (Beamish, 1983) ages over time.

Materials and Methods

An otolith exchange is a group of otoliths from a species which are evaluated by an aging group in order to provide a measure of precision of those members' aging (Tables 1,2 & 3).

Otolith exchange methodology:

- 1) a group of 50 otoliths which have been read by one reader is selected as an otolith exchange, these otoliths are selected at random,
- 2) all members of the aging workgroup read these otoliths (including the original reader),
- 3) a mode is arrived at from the results of the age readings made by the individual agers,
- 4) each individual reader's results are compared to this mode,
- 5) the original reader's aging is compared to his/her second aging of the exchange (precision).

Therefore the original reader has 3 individual comparisons:

- 1) agreement with self,
- 2) agreement with mode,
- 3) original reading's agreement with mode.

The number of otolith readings over and under the modal value is considered in each individual evaluation. This will give an indication of bias versus the mode; either reading consistently over or under the mode (Table 4). A lack of bias would be indicated when the number over is close to or equals the number under the mode.

Over the course of a year a minimum of four exchanges should be attempted. These exchanges should vary on the following factors:

- 1) NAFO area,
- 2) inshore or offshore catch,
- 3) gear type,
- 4) original reader,
- 5) time of year sample caught.

A comprehensive record of otolith exchange results from 1978 onwards has been maintained. This allows a review of any accredited reader's performance to be compared with all past readers since 1978 (Tables 5&6). An individual's performance will fluctuate over time and the historical record allows the magnitude of these fluctuations to be assessed in a balanced manner. All of the above considerations are reviewed in order to arrive at a consistency of age determination among the aging workgroup.

The composition and number of individuals composing the age reading group has changed over the years (Table 5). In addition to otolith exchanges a constant individual exchange of particularly hard to read otoliths occurs. Readers are encouraged to read from a variety of NAFO areas (Table 7) in order to appreciate the apparent differences in growth rates (Lopez-Veiga, 1977) which affect the patterns of annular development.

Training an age reader to a point of competency takes a great deal of time. There are several stages to this training (R.Wells, 1977. Memorandum):

a) introduction to the biological basis of determination of age of fish from skeletal structures, including pattern of fish growth and corresponding otolith growth, seasonally and from year to year,

b) consideration of the 40 annotated photographs examined in detail at the Vigo Workshop in addition to 95 photographs of cod otoliths evaluated by R. Wells at the Newfoundland Laboratory (Wells, 1997 NAFO Sci. Coun. Studies, No.1; 77-101),

c) demonstrating the setup of equipment, method of preparing otoliths for age determination, use of microscopes-magnification, angle of illumination etc.,

d) examination of otoliths which have been previously aged by senior readers, the number and variety of otoliths will vary over the years but several hundred otoliths from each NAFO area should be examined,

e) during the above stage constant coordination with a senior reader will take place (i.e. use of a double microscope to demonstrate interpretation of otoliths),

f) independent age determinations made by apprentice readers are compared to the age determinations of a senior reader (otolith exchanges are also used but the trainee's ages are not included in the ages used to derive the modes),

g) when a consistent agreement of trainee ages to ages from senior readers (and exchanges) exceeds 80% a single large group of otoliths (800+) are aged first by the trainee and then later aged by a senior reader. The agreement on ages must be at least 80% with no bias (Geddes, 1993), continuing evaluation will consist of exchanges that include the new readers' ages in determining the mode.

The availability of readers to participate in exchanges from year to year varies and in recent years increased workload demands has severely restricted the number of exchanges conducted (Table 8). The informal exchange of otoliths between readers has been helpful in maintaining consistency of aging between readers but a coordinated effort to increase the number of formal cod otolith exchanges will take the highest priority in the Newfoundland Region.

Conclusions

The results of otolith exchanges generally have exceeded requirements (Geddes, 1993.). The composition of the aging workgroup has changed over the years but agreement to the mode has been consistent (Fig.3). Self-agreement has not decreased since 1978 (Fig.2) but an increase in the number of exchanges is required.

The total number of otoliths read in recent years has increased (Fig.1) as the composition of the aging workgroup has changed, however the quality of interpretation has been maintained. In further years an increase in the annual number of exchanges and stability in the composition of the aging workgroup will increase the consistency of interpretation of ages.

The results of the historical five exchanges (Table 9 and Fig.4) show a great variation in agreement with the mode derived by the current readers. The agreement of the mode derived by current readers and the mode derived from the historical mode is 64% to 90% (Table 9). A strong bias is shown by some individual readers (Fig.5), though when the new and old modes are compared this bias is not strong.

Rereading these old exchanges was attempted in order to validate aging by the current aging workgroup (Beamish 1983). The agreements from the historical exchanges are 78% or better in the majority of cases (18 out of 25 comparisons) with only one reader showing consistent bias.

The general observation of all readers was that the historical otoliths being examined were consistently more difficult to read than current collections. This was due to the presence of numerous splits and checks in the annuli. Difficulty of interpretation of the annuli was considered to be greater than that of current collections. It is noteworthy that exchange #30 was considered the most difficult of the five historical exchanges read.

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Table 1. Documentation of otolith exchange number 65,3Ps 1996 cod otoliths.
Reader

Specimen No.	Reader				Mode
	C.H.	H.H.	G.C.	R.E.	
3	4	5	5	4	-
8	6	6	6	6	6
13	7	7	7	7	7
18	6	6	6	6	6
23	6	6	6	6	6
28	7	7	8	7	7
33	8	9	8	7	-
38	8	8	8	8	8
43	7	7	7	7	7
48	9	9	9	8	9
53	7	7	7	7	7
58	7	8	7	7	7
63	7	7	7	8	7
68	7	8	8	8	8
73	11	11	11	11	11
78	8	8	8	8	8
83	10	11	11	11	11
88	9	9	9	8	9
93	10	11	9	12	-
98	5	5	5	5	5
103	6	6	6	6	6
108	7	7	7	7	7
113	6	6	6	6	6
118	7	7	7	7	7
123	7	7	7	7	7
128	7	7	7	7	7
133	8	8	8	7	8
138	8	8	8	7	8
143	8	8	8	8	8
148	8	8	9	9	-
153	9	9	9	9	9
158	9	9	9	9	9
163	7	7	8	7	7
168	7	7	7	7	7
173	7	7	8	7	7
178	9	9	9	9	9
183	9	9	9	9	9
188	9	10	10	10	10
193	8	8	8	8	8
198	8	8	8	8	8
203	9	9	9	9	9
208	9	9	9	9	9
213	6	6	6	6	6
218	6	6	6	6	6
223	6	6	6	6	6
228	8	8	9	8	8
233	7	7	8	7	7
238	8	8	8	8	8
243	7	7	7	7	7
248	7	7	8	7	7

Table 2 . Results of cod otolith exchange # 65 (1997,3Ps) , agreement with modal values.

Reader	# compared	# agreed	Over	Under	% agreement
C.H.	47	41	2	4	87
H.H.	47	42	4	1	89
G.C.	47	39	8	0	83
R.E.	47	44	1	2	94
Submission					
Data	47	41	2	4	87
C.H.1\C.H. 2	50	42	4	4	84

C.H.1: original readings

C.H.2: readings made for exchange

Table 4. Bias against the mode per reader using the records of two long-term readers.

Year	H.H.		# assessed	N.B.	
	#over	#under		#over	#under
1981	40	9	282	14	12
1982	28	13	213	13	5
1983	41	21	327	19	11
1984	29	3	130	10	5
1985	1	18	79	13	1
1986	12	24	142	9	1
1987	3	39	191	24	8
1988	13	1	89	8	5
1990	9	7	136	21	1
1991	10	4	93	14	6
1992	12	1	96	3	1
1993	6	1	88	16	2
1994	2	2	41	3	1
1996	3	1	49	3	1

Table 5. Reader percentage agreement with mode 1978-1997.

# of exchanges per year	Year	Reader								
		N.B.	C.B.	R.T.	H.H.*	G.C.*	C.H.*	R.W.	C.W.	R.E.*
7	1978	92	92.4	66.4				86.4	82.7	
7	1979	92.7	85.7	65.7				87.3	74.7	
7	1980	86	86	74.1				-		
7	1981	90.8	85.1	79.1	82.6			-		
5	1982	91.5	84	75.6	80.8			-		
6	1983	90.8	89.6	76.1	81			88.8		
3	1984	88.5	-	74.6	75.4			-		
2	1985	82.3	88.6	86.1	76			-		
3	1986	93	93	74.7	74.7			-		
4	1987	88.9	73.3	79.9	78			88.1		
2	1988	85.4	80.9	77.5	84.3					
-	1989	-	-	-	-					
3	1990	83.8	-	82.4	88.2					
2	1991	78.5	-	79.6	84.9					
2	1992	95.8	85	82.3	86.5	88.5	86.5			
2	1993	79.5		85.2	92	89.8	78.4			
1	1994			80.5	90.2	90.2	61			
-	1995			-	-	-	-			
1	1996				91.8	91.8	81.6			89.8
1	1997				89	83	87			94

* current 1997 cod aging workgroup.

Table 7. Number of cod otoliths read during 1995-97.

Reader	<u>3Ps</u>	<u>2J</u>	<u>3K</u>	<u>3L</u>	<u>3NO</u>	Total
N.B.		922	401	379		1702
G.C.				937	841	1778
H.H.	4216	30	591	1177		6001
R.E.	179		383			562
1995 Total	4395	992	1375	2493	841	10043
N.B.		962	819	1579		3360
G.C.	194			1049	973	2216
H.H.	3576	30	615	2335	163	6719
R.E.	348		994	100		1442
C.H.	1147					1147
1996 Total	5265	992	2428	5063	1136	14884
G.C.	954					954
H.H.	5862	343	499	2072	314	9090
R.E.	1256	70	361	1921	95	3703
C.H.	835	191	1262	318	220	2826
1997 Total*	8907	604	2122	4311	629	16573

* preliminary numbers

Table 8. Number of exchanges conducted per year.

<u>Year</u>	<u># of exchange s</u>	<u>Year</u>	<u># of exchanges</u>
1978	7	1988	2
1979	7	1989	0
1980	7	1990	3
1981	7	1991	2
1982	5	1992	2
1983	6	1993	2
1984	3	1994	1
1985	2	1995	0
1986	3	1996	1
1987	4	1997	1

Table 9. Historical exchange results.

Exchange #	Year	Area	%	R.E. Agreement		# otoliths read
				over	under	
# 2	1978	3K	83	7	0	42
# 16	1980	2J	87	3	3	45
# 28	1981	3Ps	82	7	1	44
# 30	1982	2J	64	16	0	44
# 32	1982	3L	78	7	3	45
		Average	78.8	Total=40	Total=7	Total=220

Exchange #	Year	Area	%	H.H. Agreement		# otoliths read
				over	under	
# 2	1978	3K	88	2	3	42
# 16	1980	2J	80	3	6	45
# 28	1981	3Ps	82	7	1	44
# 30	1982	2J	82	5	3	44
# 32	1982	3L	89	3	2	45
		Average	84.2	Total=20	Total=15	Total=220

Exchange #	Year	Area	%	G.C. Agreement		# otoliths read
				over	under	
# 2	1978	3K	93	1	2	42
# 16	1980	2J	91	2	2	45
# 28	1981	3Ps	91	2	2	44
# 30	1982	2J	86	1	5	44
# 32	1982	3L	87	6	0	45
		Average	89.6	Total=12	Total=11	Total=220

Exchange #	Year	Area	%	C.H. Agreement		# otoliths read
				over	under	
# 2	1978	3K	57	2	16	42
# 16	1980	2J	73	12	0	45
# 28	1981	3Ps	66	0	15	44
# 30	1982	2J	59	2	16	44
# 32	1982	3L	71	0	13	45
		Average	65.2	Total=16	Total=60	Total=220

Exchange #	Year	Area	%	Old Mode Agreement		# otoliths read
				over	under	
# 2	1978	3K	86	5	3	32
# 16	1980	2J	78	5	4	41
# 28	1981	3Ps	90	2	2	36
# 30	1982	2J	64	6	6	40
# 32	1982	3L	78	7	2	42
		Average	79.2	Total=25	Total=17	Total=191

Figure 3. Reader % agreement with mode 1978-1997.

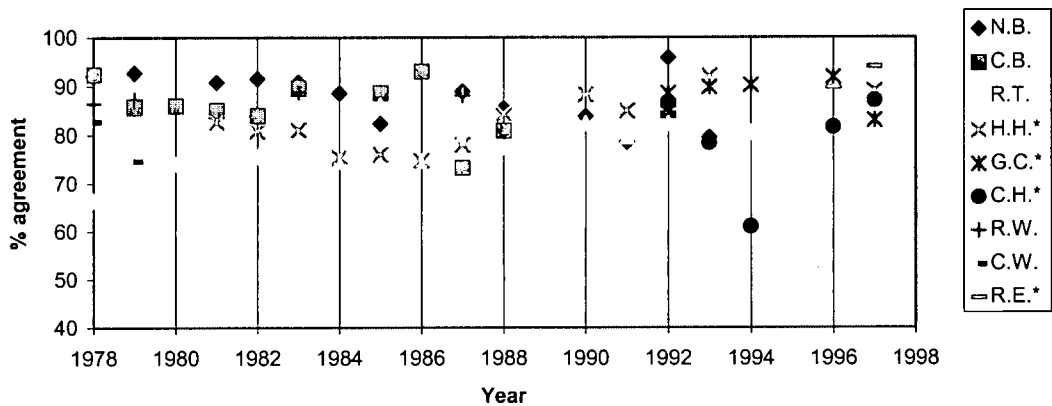


Figure 4. Percentage agreement of readers and agreement of new mode with old mode.

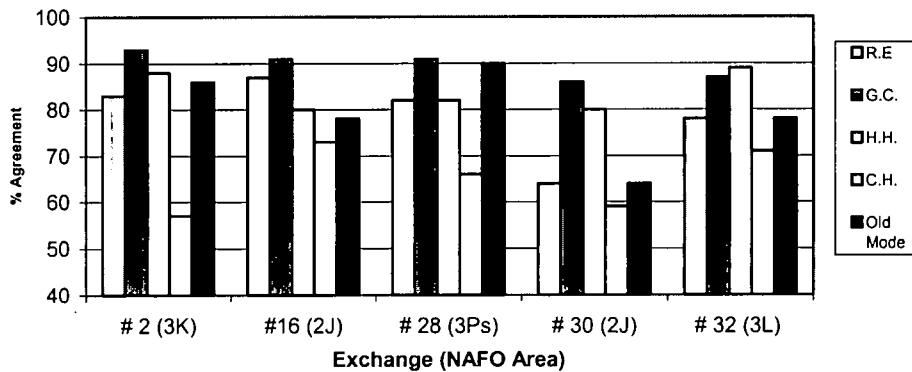


Figure 5. Bias of current age workgroup in relation to historical exchanges.

