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Ageing update of CJM and estimation of age error Matrix

Republic of Chile

Ageing Update of the Chilean Jack Mackerel (*Trachurus murphyi*) and estimation of Age Error Matrix.

Camilo Rodríguez-Valentino

Instituto de Fomento Pesquero, Chile

INTRODUCITON

Catch-at-age data is crucial for Chilean jack mackerel (*Trachurus murphyi*) stock assessment. Chilean Jack mackerel age estimation have proven to be a difficult task, which has led to many studies in order to establish and validate otolith reading protocols (FIPA 2014-32, FIPA 2017-61, FIPA 2021-21). As a result, a new otolith reading protocol has been proposed, based in micro-increment readings and bomb radiocarbon to validate *annuli* interpretation (Cerna et al. 2022). Age estimation errors can lead to errors in the estimation of catch and stock weights at age, maturity at age, and any age-structured catch-per-unit-effort (cpue) indices. Hence, age-reading problems may influence virtually all the assessment inputs (Reeves 2003). To address this issue, an age error matrix is used in stock assessment to weigh the probability that a fish of "true age" is wrongly assigned to one of the observed classes (Vitale et al 2019). As consequence of the change in the otolith reading protocol, the jack mackerel age error matrix has been updated.

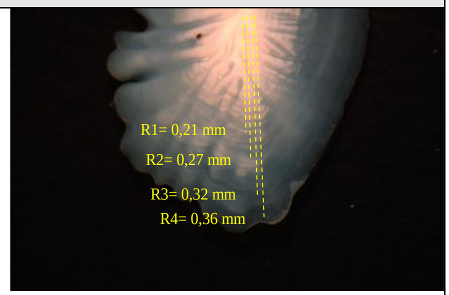
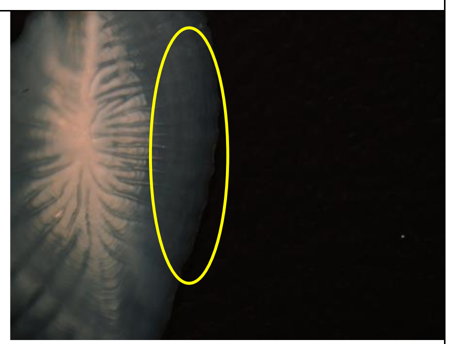
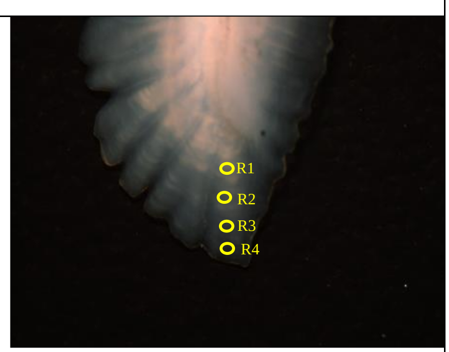
ANNULI INTERPRETATION CRITERIA

Whole otoliths

The right otolith external side is used for the interpretation. The first step is to identify the annual growth increments in the caudal area of the otolith. The continuity of the increment is followed on the ventral side of the otolith, where the nature of the marginal increment appears more clearly. The true annual increments are clearly distinct in the rostral area (Table 1). Therefore, the main interpretation criteria are: clarity and continuity of the increment along the caudal to rostral area. The increment measurements might allow to check the position of the increment and compare results between readings.

The otoliths of jack mackerel are characterized by the presence of numerous growth rings, which are zones of rapid and slow growth that correspond to the opaque and hyaline rings. A zone is often limited by an opaque ring a little thicker and a hyaline ring thin and crisp. The formation of these zones makes difficult the interpretation of the edge ring that only stands if it is complete in comparison with the previous areas.

Table 1. Steps in the whole otolith reading as applied in IFOP. R1 and R3 are false or "winter" rings. R2 and R4 correspond to true annuli (Cerna et al., 2022)

Otolith zone	Example
1-Observe Cauda and measure increments	
2-Check increment continuity in the ventral side	
3-Check the continuity of the increments in the rostrum	
4-Check the increments in the inner side of the otolith	

Transversal slices of otoliths

The translucent zones of the otoliths appear brownish after burning. The whole left otolith is read in comparison with the sectioned right otolith. The glass slide with the cut surface of the otolith is covered with oil or glycerin. The translucent increments are enumerated close to the external side or near the sulcus acusticus area (**Figure 1**). Close examination of the sulcus edge might help identifying the increments by variations on the edge surface.

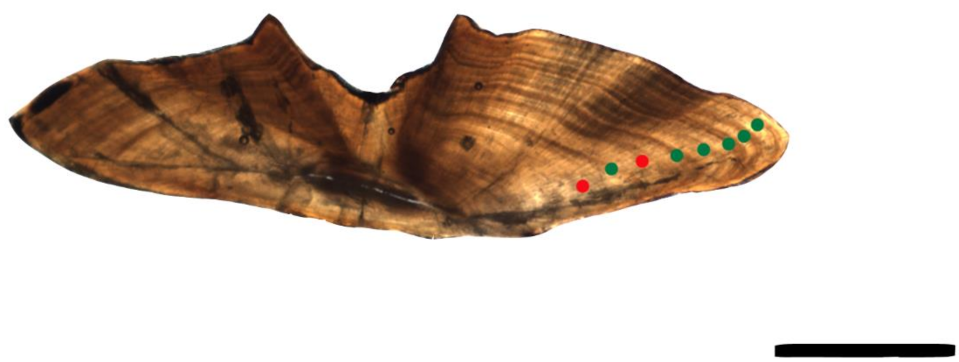


Figure 1. Transversal section of a toasted and sliced otolith showing the "winter" rings (Red dots) and annual increments (Green dots). Ventral side to the left (IFOP).

In sections the nucleus appears very opaque and its rather difficult to distinguish false rings from annuli, however the location of the first annual increment requires to consider its distance from the focus, using as reference half the caudal radius of the same ring. The following rings are rather fuzzy but distinguishable. Usually from the 2nd ring onwards these are regularly spaced.

PRECISION RESULTS FROM THE NATIONAL WORKSHOP

Ageing precision and bias

Ageing precision between readers was low for acceptable standards in other species (CV < 5%), nevertheless, where better than ageing precision reported for other *Trachurus* species from the North Atlantic by ICES 2018 which show similar ageing difficulties as the CJM (Table 2). CRV and LMR from IFOP had similar precision levels with both technics, but where biased with sectioned ones. LC and ESA are experienced readers from INPESCA, and had good precision levels with both technics and were not biased. Overall, the precision levels and bias where better between experienced readers from the same institution. Nonetheless, the best precision was between ESA and LMR in sectioned otoliths. These results are promising, and shows that experienced readers have acceptable precision levels, but more reading exercises and practice are needed to reduce bias between readers and institutions.

Table 2. Age precision and symmetry test results between all the workshop participants. Bold Evans-Hoening shows bias.

	Whole Otoliths		***Sectioned Otoliths***	
	CV	**EVANS-HOENING**	**CV**	**EVANS-HOENING**
CRV-LC	13.9	**0.00**	12.1	**0.00**
CRV-ESA	12.91	**0.00**	10.31	0.13
CRV-FCT	11.47	**0.00**	11.18	0.36
CRV-LMR	9.46	0.56	10.41	**0.01**
CRV-MAC	11.9	0.37	17.69	0.28
LC-ESA	9.26	0.75	10.74	0.27
LC-FCT	10.83	0.37	16.36	**0.00**
LC-LMR	12.32	**0.00**	11.43	0.54
LC-MAC	14.06	**0.01**	23.83	**0.00**
ESA-FCT	10.98	0.15	13.64	**0.04**
ESA-LMR	10.75	**0.00**	8.47	0.92
ESA-MAC	13.09	**0.00**	14.32	0.31
FCT-LMR	12.78	**0.03**	12.83	**0.00**
FCT-MAC	12.97	0.22	17	**0.02**
LMR-MAC	11.23	0.312	16.49	0.635

METHODOLOGY AND RESULTS

A subsample of 199 otoliths from the Instituto de Fomento Pesquero (IFOP)'s jack mackerel otolith reference collection was randomly selected, and read by 2 experienced readers following the new otolith reading criteria. The readings from the most experienced reader where considered the "true age". An age frequency table was generated based on these readings (Table 2), and the age error matrix calculated (Table 3).

Table 2. Age frequency table.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0		3												
1		2	10	1										
2		3	15	3										
3		1	2	4	3	1								
4			1	5	17	3								
5				2	16	9	6							
6					2	14	9	4	1					
7					2	6	9	2	3					
8						1	7	6	5					
9							1		2	2	1	1		
10								2		1				
11										2	1			
12								1	1	2	3			
13										1				

Table 3. Jack mackerel age error matrix.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0		0.333												
1		0.222	0.357	0.067										
2		0.333	0.536	0.2										
3		0.111	0.071	0.267	0.075	0.029								
4			0.036	0.333	0.425	0.088								
5				0.133	0.4	0.265	0.188							
6					0.05	0.412	0.281	0.267	0.083					
7					0.05	0.176	0.281	0.133	0.25					
8						0.029	0.219	0.4	0.417					
9							0.031		0.167	0.25	0.2	1		
10								0.133		0.125				
11										0.25	0.2			
12								0.067	0.083	0.25	0.6			
13										0.125				

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