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SC 12 – WP 04

PROPOSAL FOR THE WORKSHOP ON READING OTOLITHS OF JACK MACKEREL (TRACHURUS MURPHYI) BETWEEN AGE AND GROWTH LABORATORIES OF THE SPRFMO

TERMS OF REFERENCE DOCUMENT - IMARPE

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PROPOSAL FOR THE WORKSHOP ON READING OTOLITHS OF JACK MACKEREL (*TRACHURUS MURPHYI*) BETWEEN AGE AND GROWTH LABORATORIES OF THE SPRFMO

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SUMMARY

Growth parameter estimates of jack mackerel (*Trachurus murphyi*) from otolith age readings are essential to understand and characterize the population in the context of SPRFMO. Despite the multiple studies carried out to obtain more accurate results on age and growth, there is still no consensus among SPRFMO members on the results obtained to date. In the last meetings of the Scientific Committee (SC), it has been proposed to address this issue through joint workshops on age readings between the organization's laboratories. In this regard, the Chilean delegation is proposing to hold an otolith reading workshop (SC12_JM09) in the context of the 12th SPRFMO-2024 SC meeting. This initiative contemplates the direct reading of processed samples, using images obtained through methodologies and techniques that have not yet been agreed upon by all laboratories involved in age and growth assessment. In this regard, the Peruvian delegation expresses its commitment to make the necessary efforts to address this problem and is willing to carry out joint work with all members of the SPRFMO. It considers it essential to address this situation in an orderly and phased manner, with a short- and medium-term focus, as detailed in this document.

I. Background

The jack mackerel *Trachurus murphyi* Nichols 1920 is widely distributed in the southeastern Pacific, extending to the westernmost Pacific Ocean, reaching the coasts of New Zealand and Australia (Evseenko, 1987; Serra, 1991; Elizarov et al., 1993; Gerlotto and Dioses, 2013). Since 2013, within the SPRFMO SC, several discussions have been held on the estimation of growth parameters to obtain commonly accepted estimates (SPRFMO 2013, 2022). For example, efforts have been made to determine age and estimate growth parameters of jack mackerel, mainly based on whole otolith readings. Given the differences observed in the results so far and the need to understand biological parameters within the framework of stock population discussions (SPRFMO, 2008), validation studies of the first growth marks at the microincrement level in jack mackerel otoliths have been carried out, and these have been discussed since the first SC meeting (SPRFMO, 2013, 2023). However, consensus has not yet been reached, and several criteria or approaches continue to be applied in the interpretation of microincrements in the validation processes, as well as the assumption of annual growth marks.

Despite the considerable efforts made to accurately determine the age of jack mackerel, the results are not entirely clear, and errors in age estimation may lead to errors in the estimation of stock catch and weight at age, maturity at age, and any catch-per-unit-effort (CPUE) index structured by age, which would affect virtually all evaluation inputs (Reeves, 2003). Therefore, at the recent SC meetings, the need to address this issue has been emphasized by organizing age reading workshops. In the context of the 12th SPRFMO SC meeting in 2024, Chile is proposing to hold an otolith reading workshop with the objective of “Proposal of terms of reference for the Jack mackerel (*Trachurus murphyi*) otolith reading workshop between SPRFMO ageing laboratories” (SC12_JM09).

This proposal suggests conducting direct readings of processed samples based on images obtained using methodologies and techniques that have not yet been agreed upon by all age and growth laboratories within the organization. These methodologies include readings of whole otoliths in the sagittal plane, age analysis based on images, and readings in transverse sections. In this regard, studies carried out to date on jack mackerel age and growth (Table 1) have identified two main issues related to age validation and assignment. The first concerns the methodological approach, encompassing both otolith processing and the assignment of growth marks in the sagittal plane; this affects both the validation of the first annuli through microstructures and the reading of annual marks in whole otoliths. The second issue relates to the sampling design, which must consider the size structure throughout its distribution and the sample size in the estimates.

In the validation processes of the first annulus, the method of readings in the sagittal plane of the otolith has predominated. However, this approach presents some uncertainty in its results due to factors related to sample processing, the tools used, and interpretation. Firstly, the interpretations of the growth marks are susceptible to issues such as over-polishing, the incidence of light from the optical microscope, contrast adjustment, microscope resolution, and the observation of “visual artifacts” (Campana, 1992). Additionally, the angle of processing and observation of the sample in the sagittal plane also influences the results (Panfili et al., 2002).

This issue has been evident in almost all validation studies using microstructures (Goicochea et al., 2013; Goicochea et al., 2016; Cerna et al., 2016; Araya et al., 2019; Cerna et al., 2022). Regarding interpretation, a criterion established by Cermeño et al. (2008) has been followed to assign daily growth marks to structures that could be an unfortunate product of processing and visualization effects under an optical microscope, referred to as individual marks or band groups. Furthermore, readings of annual marks in the same sagittal plane also present limitations; they are not recommended for otoliths of older fish, as the growth pattern in older fish changes, becoming indistinguishable in many cases, which may lead to underestimation of age.

Regarding validation using radiocarbon, which was presented at the last SPRFMO SC meeting, some uncertainty in the results is noted. Cerna et al. (2022) presented an update of the growth model for Chilean jack mackerel based on the 2016 results as the “right” ones; however, the estimates show some bias in the determination of the first two hyaline marks. Radiocarbon 14 varies in a non-uniform latitudinal manner in the Pacific Ocean (Broecker et al., 1985), making it inadvisable to use the radiocarbon 14 assimilation model of *Hippoglossus hippoglossus* (used to normalize ^{14}C) as a reference for jack mackerel, as both species are ecologically distinct (demersal and pelagic, respectively) and from opposite latitudes, and ^{14}C assimilation in fish occurs through diet (Campana, 1999), so prey selectivity is a key factor to consider in these studies. Moreover, the average lifespan of ^{14}C in the environment is 5700 years, with very low sensitivity and uncertainty levels of ±30 years (Hajdas et al., 2021), which does not help when dealing with relatively short-lived organisms where a few years are under discussion. Therefore, it would be more appropriate to use another isotope with a shorter lifespan.

Regarding sampling design, it is crucial to analyze the size structure across the entire distribution area for estimating growth parameters. The stock in the Southeast Pacific is primarily composed of individuals smaller than 45 cm TL (Gerlotto and Dioses, 2013), while in western waters, the size structure is larger, exceeding 50 cm FL, and has been increasing in landings on the coasts of New Zealand over recent years (Horn et al., 2019). Horn and Maolagáin (2020) suggest that the population in areas of the Southeast Pacific comprises the smallest sizes, corresponding to the youngest groups. However, the size structure of jack mackerel is not entirely clear, which could affect the estimated growth parameters for the Southeast Pacific population, depending on the structures used. Additionally, in the validation processes of the annuli, the necessary size range for accurate estimation has not been adequately covered (Goicochea et al., 2013; Goicochea et al., 2016; Araya et al., 2019; Cerna et al., 2022).

In this context, it is crucial to unify the criteria for determining the age of jack mackerel, with the goal of obtaining accurate biological parameters that allow for proper characterization of population units and improving their management and conservation. This could be achieved through consensus-based initiatives in an otolith reading workshop, where the issue is addressed by reviewing previous studies, evaluating methods and techniques in the validation process, and establishing a reading protocol.

Regarding document SC12_JM09 presented by the Chilean delegation, the Peruvian delegation expresses its commitment to make the necessary efforts to address this issue and is willing to carry out joint work with all SPRFMO members. From our perspective, it is essential to approach this situation in an orderly manner and in stages, with a short- and medium-term focus, as detailed in this document.

We recommend that Dr. Jacques Panfili, a French specialist from IRD - UMR MARBEC and the Federal Rural University of Pernambuco in Brazil, who has been working on this issue, accompany this process.

II. Workshop Objectives

The objective of the workshop is to establish the interpretation criteria for growth marks in *Trachurus murphyi* otoliths used for age determination by the age and growth laboratories of the SPRFMO member countries, which will be reflected in an age reading protocol for otoliths. Therefore, the workshop aims to:

a. Analyze the methods and validation processes of annuli using microincrements.
b. Standardize the criteria for interpreting growth marks in otoliths.
c. Obtain a consensus-based protocol for reading age in *Trachurus murphyi* otoliths.

III. Workshop Organization

The workshop will be conducted in three stages, either virtually and/or in person (Table 1), as appropriate:

A. Analysis of validation through microstructures: In this first stage, the approach, methods, and criteria used in the validation process and the assignment of age in macro rings will be analyzed. This will allow us to identify and assess the main problems associated with age validation. This stage will be conducted virtually and should establish:

1. A review and analysis of the dating methods or techniques in jack mackerel, as well as a review of the validation of jack mackerel age.

2. Discuss the criteria or approaches used in the interpretation of microincrements and identify the issues in determining age.
3. Establish a "work plan" for the direct observation of microstructure samples, which will include preparation techniques, interpretation criteria to be used, and the sample structure from each jurisdiction. Strategies for validating hyaline marks should also be considered, with a focus on selecting suitable samples.

B. Standardizing criteria: This second stage must be conducted in person, as it involves the direct handling of samples, given that the technique, tools used, and manipulation of the samples are under discussion. This stage will involve the processing and analysis of otolith microstructures based on the work plan developed in the previous stage and must take place in a research laboratory in age and growth that is a member of the SPRFMO. This process should be accompanied by a neutral external expert, previously chosen by agreement among the workshop participants, and should establish:

1. Analysis of the samples, characterization by geographic area, analysis of growth marks, morphometric analysis of otoliths.
2. Preparation of otolith samples for microstructure analysis using previously agreed-upon techniques. Each representative country group must have a battery of samples within a size range discussed in the "work plan."
3. Interpretation of growth marks in microstructures and macrostructures in otoliths, previously designed in a work scheme for the treatment of whole samples from each jurisdiction.
4. Establish consensus-based interpretation criteria for growth marks among all SPRFMO members.

C. Drafting an age-reading protocol for jack mackerel: This final stage will be conducted virtually, based on the agreements established in the previous stage. The following must be accomplished in this phase:

1. Draft the protocol for reading *Trachurus murphyi* otoliths, taking into account the nature of the sample based on the area where it was captured.
2. Present the document promptly to all SPRFMO SC members for discussion, approval, and application within the SPRFMO.

IV. Activity calendar

Table 1: Activity plan for the reading workshop of jack mackerel otoliths *T. murphyi* Aug 2024 – Mar 2025

Stage	Activities	Mode	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Preparation of TDR	Workshop coordination	Virtual	x	x						
	Workshop agreements at the SC meeting	In-person			x					
Analysis of validation by microstructures	Review and analysis of methods	Virtual			x					
	Identifying problems associated with validation	Virtual			x					
	Establish a work plan for direct observation	Virtual			x					
Standardize criteria	Sample analysis and characterization	In-person				x				
	Preparation of otolith samples	In-person				x				
	Analysis and interpretation of microstructures	In-person							x	
	Analysis and interpretation of macrostructures	In-person							x	
	Report of results and agreements	Virtual							x	
Development of otolith reading protocol	Writing the document	Virtual								x
	Presentation of the document to the SC	Virtual								x

V. Workshop report and documents

A report will be drafted with the agreements from each stage. At the end, a unified protocol for age assignment in jack mackerel *T. murphyi* must be developed in collaboration with the members of the SPRFMO.

VI. Annex

Table 1: Studies on age and growth of jack mackerel *T. murphyi* conducted by several authors, updated from Dioses et al. (2013) and Cerna et al. (2016).

N°	Authors	Structure	Method	Loo	k	to	Area
1	Kaiser (1973)	Otolith	Sagital section	70,1	0,184	-0,341	Northern - Central Chile
2	Carrera et al. (1978)	Otolith	Sagital section	108,3	0,109	-0,877	Central Chile
3	Abramov & Kotlyar (1980)	Otolith	Sagital section	72,5	0,093	-2,233	Peru
4	Aguayo & Ojeda (1981)	Otolith	Sagital section	45,9	0,167	-0,882	Northern Chile
5	Nekrasov (1982)	Scale	Whole section	74,3	0,086	-2,676	Peru
6	Shevchuk (1982)	Otolith	Sagital section	90,4	0,115	-1,429	Peru - Chile
7	Castillo & Arrizaga (1987)	Otolith	Sagital section	65,2	0,074	-2,410	Southern Chile
8	Nekrasov (1987)	Scale	Whole section	96,0	0,060	-2,617	Peru
9	Nosov (1989)	Scale	Whole section	77,8	0,077	-1,613	Peru
10	Kochkin (1994)	Otolith	Sagital section	74,2	0,111	-0,811	Peru
11	Shcherbitch (1991)	Otolith	Sagital section	91,2	0,091	-1,583	--
12	Babayan & Bulgakova (1994)	Length	LFA	94,5	0,099	--	South Pacific
13	Alegría et al. (1995)	Otolith	Sagital section	78,5	0,154	-0,098	Northern Chile
14	Alegría et al. (1995)	Otolith	Sagital section	53,5	0,111	-1,797	Northern Chile
15	Alegría et al. (1995)	Otolith	Transerse section	48,4	0,184	-0,945	Northern Chile
16	Arcos & Arancibia (1995)	Otolith	Sagital section	79,9	0,068	-2,369	Central - Southern Chile
17	Arcos & Arancibia (1995)	Otolith	Transerse section	70,7	0,088	-2,107	Central - Southern Chile
18	Cubillos & Grechina (1998)	Length	LFA	78,6	0,144	--	Chile
19	Li et al. (2011)	Otolith	Sagital section	73,8	0,107	-1,080	Central - Southern Chile
20	Dioses (2013)	Otolith	Sagital section	80,8	0,155	-0,356	Peru
21	Díaz (2013)	Length	LFA	81,6	0,167	--	Peru
22	Goicochea et al. (2013)*	Otolith	Sagital section	75,2	0,165	-0,817	Peru
22	Cerna et al. (2016)*	Otolith	Sagital section				Chile
23	Cerna et al. (2016)*	Otolith	Bomb Radiocarbon				Chile
24	Goicochea et al 2016*	Otolith	Sagital section				Peru
25	Goicochea et al 2016*	Otolith	Transerse section				Peru
26	Cisterna & Arancibia (2017)	Otolith	Sagital section	75,0	0,160	-0,130	Central Chile
27	Araya et al 2019*	Otolith	Sagital section				Chile
28	Horn & Maolagáin (2020)	Otolith	Transerse section	51,9	0,223	-0,500	New Zealand
29	Arancibia et al. (2021)	Otolith	Daily ring	75,0	0,160	-0,190	Peru - Chile
30	Arancibia et al. (2021)	Otolith	Sagital section	74,7	0,100	-0,500	Peru - Chile
31	Cerna et al. (2022)*	Otolith	Sagital section				Chile
32	Cerna et al. (2023)	Otolith	Annual ring	64,9	0,130	-2,630	Chile
33	Cerna et al. (2023)	Otolith	Transerse section	56,9	0,170	-2,330	Chile

* Age validation studies

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