

SHORT REVIEW OF SOME BIOLOGICAL ASPECTS OF THE CHILEAN JACK MACKEREL, *Trachurus murphyi*.

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Introduction

In this review the aging procedures, size at first maturity and natural mortality used in the stock assessment of the Chilean jack mackerel are briefly described and discussed.

Age determination

The jack mackerel is rather slow growing specie and appears to be a moderately long lived. In Chile the maximum age read for the jack mackerel of the southeastern Pacific is 19 years. This coincides with Nekrasov (1984; in: Arcos and Grechina (eds.) 1994). Taylor et al (2002) report readings of 32 years old fish caught in New Zealand waters.

The age determination in Chile is done by the Fisheries Development Institute (*Instituto de Fomento Pesquero*), IFOP, based on the readings of whole otoliths (sagittae). The number of rings are counted and the condition of the otolith border is recorded (hyaline, opaque; narrow, wide). The validity of the formation of annual rings is based on the analysis of the border of the otolith, which shows the formation of only one hyaline and one opaque zone per year (Aguayo et al., 1981; Alegría et al., 1995; Serra and Gili, 1995). The otoliths are described to be complex structure, with bands of rings (false rings), particularly for the first 2 or 3 ages, what seems to be a general characteristic of the genus *Trachurus* (Morales-Nin 1987, Kerstan 1995). The formation of annual rings was also checked with the analysis of micro-increments (daily rings), analysis that confirmed the identification of the first two rings read with whole otoliths (Alegría et al., 1995).

Preliminary results comparing readings of whole otoliths with transverse sections from 87 samples with a range in sizes between 30 and 65 cm FL are shown in **Table 1**. The otoliths were first “baked” in an oven, sectioned and polished. The results show good consistency in the readings between the two techniques for ages from 5 to 9 and a slight difference for the older fish. This last should not have an important effect on the result

of the stock assessment due to the use a plus group starting at age 12 (12+), besides that this ages are not well represented in the catch.

Table1. Analysis of symmetry of readings with whole otoliths (OE) and transverse sections (SPT). (Source: Aging Section, IFOP).

Edad OE	Edad SPT														Total		
	5	6	7	8	9	10	11	12	13	14	15	16	17	18		19	
5	3	4															7
6	1	8	2														11
7			3														3
8				7	1												8
9					6	2	1										9
10						3	1			1	1						6
11							1	3	2		1						7
12								1	2	4	1						8
13									2	4	3						9
14										2	4	3					7
15									1		5	2	1				7
16										1	3	2	1				3
17											2	1	1				2
18														1			1
19																	1
Total	4	12	5	7	10	4	5	5	7	7	13	4	3				87

The goodness of the age reading is also demonstrated by the evidence of strong year classes progressing through the series. Strong year classes can easily be followed from one age class to the next in consecutive years in the age composition of the catch. This was done with the exceptionally large cohorts of 1983 and 1984.

Sexual maturity

The jack mackerel is a heterosexual species without visible sexual dimorphism; is a partial spawner with undetermined fecundity. Several pieces of work have been done to describe its size at first maturity and most of them are summarized in **Table 2**. In this piece of information at least two main problems can be identified. One is the confusion with the concept of first maturity (first spawning, L_M), and second is the practical difficulty to have a maturity ogive. From the Table 2, the size at first maturity is described for fish from about 21 cm FL to 36 cm. The point is what is meant by first maturity. The smallest fish that has been found mature or starting the maturation process is 21-22 cm FL (Serra, 1991; Oyarzún et al., 1998; Oliva, 2004) and all fish larger

than 29 cm FL are adults that have spawn at least ones. According to Adrianov (1987; in Arcos and Grechina, 1994) fish of 23 cm FL were found mature and describe that massive sexual maturation occur to fish between 23 and 27 cm FL.

Table 2. Maturity size in jack mackerel related with different periods and method (extracted from Cubillos 2008).

Area	mL (LH,cm)	Period	Method	Author
Coastal waters front off Chile.	36,0	1963-1964	Macroscopic	Kaiser (1973)
Coastal waters front of Perú.	25,0 _a	1972-1973	Macroscopic, first maturity	Abramov & Kotlyar (1980)
Northern zone Chile, coastal waters.	31-32	1978-1981	Macroscopic, 50% observed	Aranis (1981)
Oceanic and coastal waters front off Perú.	39	1972-1973	Macroscopic, 50% observed	Andrianov (1985)
Oceanic waters front of Peru and Chile	23-27	1980-1983	Microscopic	Adrianov(1990) fide Grechina et al. (1998)
Coastal waters front Talcahuano, Chile	22.3-22,8 [*]	1982-1984	Histology, first maturity	Oyarzún et al. (1998)
Coastal waters front Perú	21,3 _b	1986	Histology, fit logistic model	Dioses et al. (1989)
Coastal Waters Arica-Mejillones, Chile	21,6	1993-1994	Histology, fit logistic model	Alegria et al. (1989)
Coastal Waters Arica-Mejillones, Chile	23,0	1993-1994	IGS increment between sizes	Alegria et al. (1989)
Coastal Waters, Northern Chile	24,0	1989-1990	Histology, maturity smallest female	George (1995)
Coastal waters, Northern Chile	24,5-25,0	1989-1990	IGS increment between sizes	George (1995)
Northern zone off Chile, coastal waters	23,1	1999-2000	Histology, fit logistic model	Oliva (2004)
South center zone off Chile, oceanic waters	25,4	1999-2000	Histology, fit logistic model	Oliva (2004)
Northern and southern zone off Chile	24,3	1999-2000	Histology, fit logistic model	Oliva (2004)

The conclusion is that many authors refer as first maturity a stage in which the maturation process is just starting. On the other side sizes of first maturity like 36 or 39 cm largely exceed the size of 30 cm in which all the fish have been found mature and spawning. The problem seems to be the large geographic distribution of the jack mackerel and its differential distribution by size (and age), that it disperses offshore for spawning and therefore practical difficulties exist to obtain representative samples from the population to estimate the proportions at size (or age) at which the fish are spawning. Therefore to produce a maturity ogive was considered that the fish start to spawn at about 23 cm FL with age 3; the 50% occurs at size 25 cm with age 4; and almost all fish at 29 cm and about age 5 are spawning; all fish is mature with 30 cm. The criteria for the size at 50% was taken from the work of Adrianov (1987; in Arcos and Grechina, 1994) and is the median between 23 and 27 cm size of fish. The ogive produced this way matches very well with the work of Oliva et al. (2004) for fish sampled in northern and south-center Chile.

Size	21	22	23	24	25	26	27	28	29	30	31
%M	0	33	38	46	67	83	89	96	96	100	100

On this basis the maturity ogive at age produced was:

Age	1	2	3	4	5	6	7
%M	0	0	4	50	96	100	100

The problem is that this ogive at age was created on the basis of the proportion of fish mature at size and not at age. No observations are available about the proportion of sexually mature fish at age.

Natural mortality, M

As direct measurement of M are often impossible to estimate, it has been attempted to identify quantities which can be assumed proportional to M and that are easy to estimate. Serra (1996) estimated M using Pauly's method considering the growth functions of Kochkin (1994) and Gili et al (1995; in Alegría et al., 1995) and temperature for the south center zone off Chile.

L_{∞}	K	t_0	Reference
74.24	0.1109	-0.8113	Kochkin (1994)
70.80	0.094	-0.896	Gili et al. 1995

The temperature was taken for the depth at which the jack mackerel was found in surveys carried out between 1991 and 1994 (Serra et al., 1994a and 1994b). The median and the maximum values for the temperature was used for the calculations with both growth functions and the final value adopted was the mean between both estimates and is $M= 0.23$. This value has been used by IFOP for the stock assessment of the jack mackerel. Applying Hoenigs method (Quinn and Deriso, 1999) an estimate of $M= 0.23$ and 0.22 was obtained with a longevity of 19 or 20 years. With the method of Alverson-Carney (Quinn and Deriso, 1999) the value of M obtained with K from the two growth functions and maximum age of 20 are 0.25 and 0.27 respectively. It is worth to say that this method is highly sensitive to the maximum age and the value of K . With a maximum age of 22, likely to occur due to the fact that fish over 30 years old have been reported for New Zealand (Taylor et al., 2002), the values changes to 0.22 and 0.24.

References

- Aguayo, M., E. Estay y V. Ojeda. 1981. Determinación de la edad y crecimiento del jurel (*Trachurus murphyi*) en la zona de Arica-Coquimbo y Talcahuano. Informe Subsecretaría de Pesca. Instituto de Fomento Pesquero. 88 p.
- Alegría, V. et al.. 1995. Estudio biológico pesquero sobre el recurso jurel en la zona norte (Regiones I y II). FIP. IFOP. Informe Final. 221 p. + Figs. y Tablas.
- Arcos, D., L. Cubillos., A. Sepúlveda., A. Grechina., H. Peña., R. Alarcón., A. Hernández., L. Miranda., L. Vilugron. 1995. Evaluación del jurel a nivel Sub-regional. Informe Final FIP 95-09, 219 p.
- Arcos, D.A., Cubillos, L.A., Núñez, S.P. 2001 .The jack mackerel fishery and El Niño 1997-98 effects off Chile. Progress in Oceanography 49, 597-617.
- Cubillos, L. 2008.Talla de primera madurez sexual en el jurel utilizando el consumo relativo de oxígeno. Revista Investigaciones Marinas (submitted).
- Cubillos, L. y A.S. Grechina. 1998. Crecimiento del jurel, *Trachurus symmetricus murphyi* (Nichols) del Pacífico Suroriental mediante análisis de progresión modal.

- In: "Biología y ecología del jurel en aguas chilenas", D. Arcos (Ed.), Instituto de Investigación Pesquera, Editora Anibal Pinto, Concepción, p. 151-161.
- Cubillos, L., A. Sepúlveda & D. Arcos. 1998. Producción primaria requerida para sustentar el desembarque de peces pelágicos en Chile. *Investigaciones Marinas*, Valparaíso, 26:83-96.
- Cubillos, L., Arancibia, H. 1995. Comparative growth performance of horse mackerel of the genus *Trachurus*, with emphasis on *T. symmetricus murphyi*. In: "International symposium on middle-sized pelagic fish", C. Bas, J.J. Castro y J.Ma. Lorenzo (Eds.), *Scientia Marina* 59(3-4):647-652.
- Cubillos, L.A, Paramo, J., Ruiz, P., Núñez, S., Sepúlveda, A. 2008. The spatial structure of the oceanic spawning of jack mackerel (*Trachurus murphyi*) off central Chile (1998 – 2001). *Fisheries Research* 90: 261-270
- Quinn, T. J. and R. B. Deriso. 1999. *Quantitative Fish Dynamics*. Oxford University Press. 542 p.
- Grechina, A.S., S. Núñez, & D. Arcos. 1998. Biología reproductiva del jurel (*Trachurus symmetricus murphyi*) en el Pacífico sur. In: D. Arcos (Ed.), *Biología y ecología del jurel en aguas chilenas*. Instituto de Investigación Pesquera, Talcahuano, Chile, p. 77-79
- Haddon, M. 2001. *Modelling and Quantitative Methods in Fisheries*. Chapman and Hall/CRC, Boca Raton.
- Kerstan, M. 1995. Ages and growth rates of agulhas bank horse Mackerel *Trachurus trachurus capensis* – comparison of otolith ageing and length frequency analysis. *S. Afr. J. mar. Sci.* 15: 137-156.
- Kochkin, P. N. 1994. Age determination and estimate of growth rate for the Peruvian jack Mackerel, *Trachurus symmetricus murphyi*. *J. of Ichthyology* 34(3): 39-50.
- Morales-Nin, B. 1987. Métodos de determinación de la edad en los osteictios en base a estructuras de crecimiento. *Inf. Técn. Inv. Pesq.* 143: 30 p.
- Oliva, J, Díaz, E. & Y. Muñoz. Estimación del tamaño de primera madurez sexual y fecundidad parcial de hembras de jurel en la zona norte (I y II Regiones) y centro-sur (Talcahuano) (Octubre 1999 a febrero 2000). Informe Interno IFOP, 19 p.
- Serra, J.R. 1991. Important life history aspects of the Chilean jack mackerel, *Trachurus symmetricus murphyi*. *Invest. Pesq. (Chile)*, 36:67-83.
- Serra, R. y R. Gili (eds.). 1995. Identificación de anillos anuales en otolitos de jurel. Informe del Taller de Trabajo. IFOP. Talcahuano.

Serra, R. 1996. Investigación evaluación del stock de jurel, 1995. Informe Técnico IFOP/SUBPESCA.

Taylor, P. R., M. J. Manning and P. M. Marriot. 2002. Age and growth estimation of Murphy's mackerel, *Trachurus symmetricus murphyi*. New Zealand Fisheries Assessment Report, 62 p.