Chilean Jack Mackerel Workshop

Methodology used to determine the Jack Mackerel (*Trachurus Murphyi*) age in Chile

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Introduction

IFOP has been carrying out growth-at-aging studies in different Chilean fisheries since late 1960. Currently, the age readings are being certified under NCh ISO 17025. Particularly in the jack mackerel fishery, age composition in the catches has been a relevant element for the indirect understanding of changes in the stock. There is an availability of reliable age readings since early 1970, which have been used for developing size-age keys and catch-at-age matrix per zone, constituting the input data in the stock assessment process.

In this document a summary of the main methodological details used for determining the jack mackerel age, and the results obtained in the last 10 years are provided.

Materials and Methods

1- Otoliths collection and sampling zones

On the annual jack mackerel fishery monitoring program, pairs of *sagitta* otoliths are monthly collected in 3 main zones (Bocic *et al*., 2000), Zone 1: Arica (18º30'S) – Antofagasta (24ºS); Zone 2: Caldera (25ºS) – Coquimbo (29ºS), and Zone 3: San Antonio (34ºS) – Valdivia (40ºS), are grouped in trimesters.

The otoliths are arranged on a pasteboard surface with 24 round standard-sized perforations, which are labeled on the reverse side according to sequence and origin (Ojeda *et al*., 2006) (Figure 1).

2 Subsample selection

Sample selection is based on double sampling techniques (Kimura, 1977). The first stage considers a simple random sampling for length samples. The second one considers a random sampling stratified by length class, with age subsampling in proportion with catches size composition. Considering the statistical analysis carried out by Robotham *et al*., 2006, 300 otoliths are selected by zone-trimester stratum.

Figure 1 Perforated pasteboard on a black base, containing the mackerel pairs of *sagitta* otolith.

3. Age readings

For determining age, whole otoliths transversally dissected are used; the pair of otoliths is kept submerged in transparent oil, in a Petri dish (against a dark base). During the last years, the right otolith has been analyzed, transversally dissected, polished, and toasted for fish over 45 cm, in order to achieve a greater growth rings alternation, and thus, facilitating its reading (Figure 2). After the reading is carried out, otoliths are stored for future analyses.

4. Growth Parameters

Diverse growth parameters have been identified for this resource. Gili *et al*., 1996 reported 12 age groups present in the catches, in the south-center Chilean zone, based on a 2896-otolith

sampling, which growth is adjusted to the Von Bertalanffy model, according to the following parameters: L_∞ = 70,8 cm; K= 0,094; t_o= -0,896.

a

b

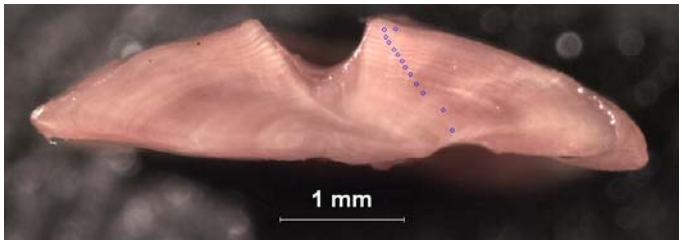


Figure 2. Jack Mackerel otoliths (a) whole otolith (b) right otolith transversal section.

5. Jack Mackerel Age Validation

The reading of otoliths annuli (rings with annual periodicity) is used to estimate age, but its correct interpretation is not easy and may result in errors. For this, ^{14}C techniques based on the radiocarbon bomb are used in age validation. The ^{14}C was stored in the otoliths nuclei at the end the 50's allowing the establishment of a relationship between these concentration indexes and those found in the samples that are to be studied (Kalish, 1993 fide Campana, 2001; Campana, 1997; Campana and Jones, 1998; Campana, 2001).

This activity was carried out together with the "Otolith Research Laboratory" (ORL), Bedford Institute of Oceanography, Canada. The age estimated with the traditional reading method was compared to dating with radiocarbon bomb and validating the growth reported by IFOP.

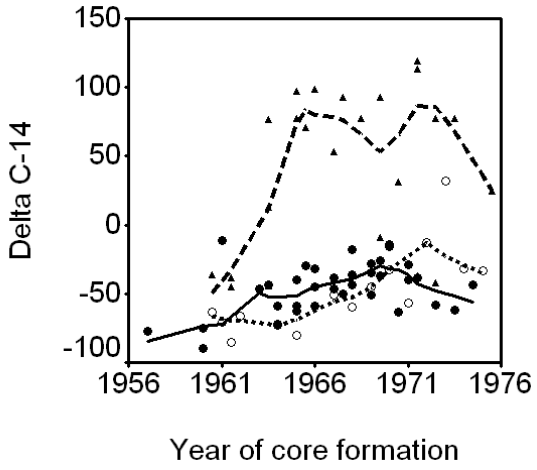


Figure 4. Chronology based on radiocarbon bomb, with otoliths from young and nuclei from adults, from anchovy (○), jack mackerel (▲), and common hake (●).

6. Precising age determination

There exist different methods to measure age readings precision. For exmample the one proposed by Beamish and Fournier (1982), through a mean error estimator:

$$APE = \frac{100}{N}\sum_{J=1}^{N}\left[\frac{1}{R}\sum_{i=1}^{R}\frac{\left|X_{ij} - X_j\right|}{X_j}\right]$$

where,

N	=	is the fish assigned with fish;
R	=	is the number of times the sample was read;
Xij	=	is the i-th age determination of the j-th fish;
Xj	=	is the mean age calculated for the j-th fish;

and other is a precision index (Chang 1982) based on the variation coefficient (V)

$$D = \frac{100}{N}\cdot\sum_{j=1}^{N}\frac{V}{\sqrt{R}} = \frac{100}{N} * \sum_{j=1}^{N}\frac{1}{\sqrt{R}}\cdot\frac{\sqrt{\sum_{i=1}^{R}\frac{\left(X_{ij} - X_j\right)^2}{R-1}}}{X_j}$$

7. Size - age keys

The size-age keys are matrixes that enable individuals' classification according to their age group (AG), and calculating the probability of belonging for the different strata. They represent basic units for information integration at temporal (months) and spatial (zones) levels.

An age group comprises all the fish born in the same year (annual class). The total number of years is based on the number of rings observed in the structure, the type of edge and the time of the year in which the sample was collected. The arbitrary date of birth is 1 January. The size-age key has a classification of the each otolith readings per age group and based on that, each probability is estimated according to:

$$q_{rk} = n_{irk} / n_k$$

where:

r	=	age group
k	=	fish total length
q_{rk}	=	probability of "k" length individuals to belong to a given AG
n_{rk}	=	number of "r" aged and "k" length individuals
n_k	=	total number of "k" length individuals.

8. Catch in number estimations per age group

There are age compositions of the catches per zone available since 1975. These have been elaborated considering that individuals present in each length interval (X_k) are assigned to the different ages according to a size-age key. The number of individuals belonging to each AG according to size interval will be estimated as follows:

$$\hat{X}_{rk} = q_{rk} \hat{X}_k$$

$$\hat{X}_r = \sum_{k=1}^{k=r} \hat{X}_{rk}$$

where:

X_k	=	estimated number of individuals to k length
X_{rk}	=	estimated number of k length belonging to r age
X_r	=	estimated number of individuals to r age
q_{rk}	=	rater of k length samples belonging to r age

9. Mean weights per age groups

Weight estimation is carried out based on a mean length, which has a systematic bias for each given mean length. This bias increases with the variability in the fish length of the sample (Ricker, 1958). Pienaar & Ricker (1968) addressed this subject presenting a method that allows significantly correcting this bias. Assuming that length is a normal random variable with μ mean and σ^2 variance, L~ N (μ,σ^2), the *W*, Ψ (L), function expected value is estimated through the delta method (Wolter, 1985) as:

$$E(W) = a(\mu^{b} + a_1 \mu^{b-2} \sigma^{2} + a_2 \mu^{b-4} \sigma^{4} + a_3 \mu^{b-6} \sigma^{6} + ...)$$

where *a* and *b* are the size-age function parameters.

Results / Discussions

At a national level, currently the jack mackerel catches age structure is based on three age groups (IV,VII and VI), which represent 53% of the catches in number. By its side, the age structure of the main landings zone (South center zone) has showed an important reduction in terms of the age groups participating, and is only based on two age groups, VII and VI, which accumulate 50% of the catches in this zone; while in the northern zone (Arica-Coquimbo), IV is the most represented age group, contributing 52%. At a national level, the lack of young samples (younger than 4 years-old) has played a role.

The VII and XIX group contribution still has low significance, but it has mildly strengthened in the south. The age structure at a national level is strongly influenced by by the high catch rates registered on the south-center zone (main fishing zone in the country), in which higher catches in terms of weight and amount of specimens are obtained. Likewise, the percentage of specimens under the minimum allowed size in the south-center zone has risen importantly and progressively since 2003 (10,0%), 2004 (6,0%), 2005 (0,3%) and 2006 (0,2%) (Aranis *et al*., 2007).

Acknowledgments

To the scientifics' labor, and that of the personnel of the Laboratorio de Edad y Crecimiento of IFOP, in the development of proceedings and documents to reach the certification of age determination of this resource under NCh ISO 17025.

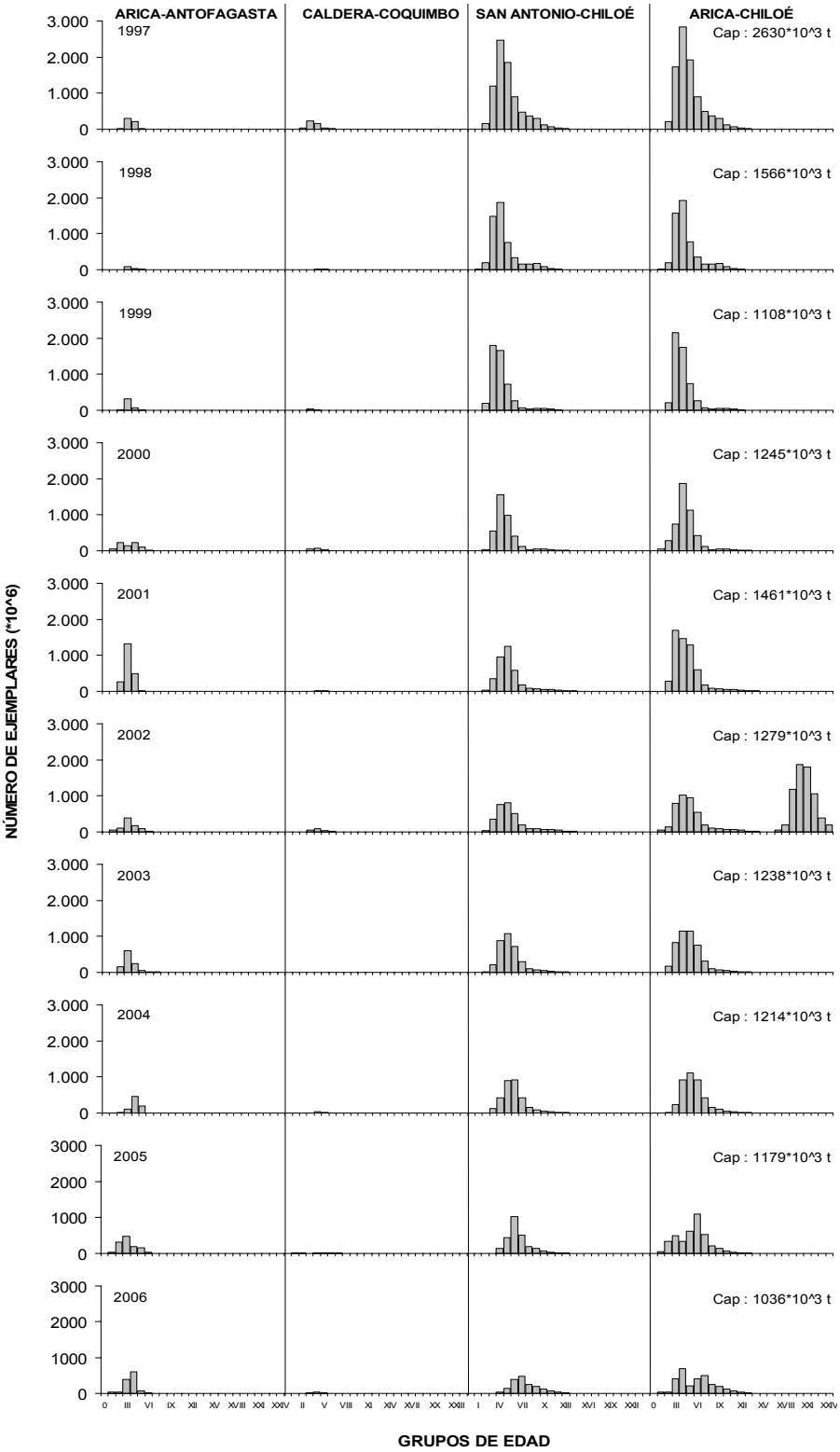
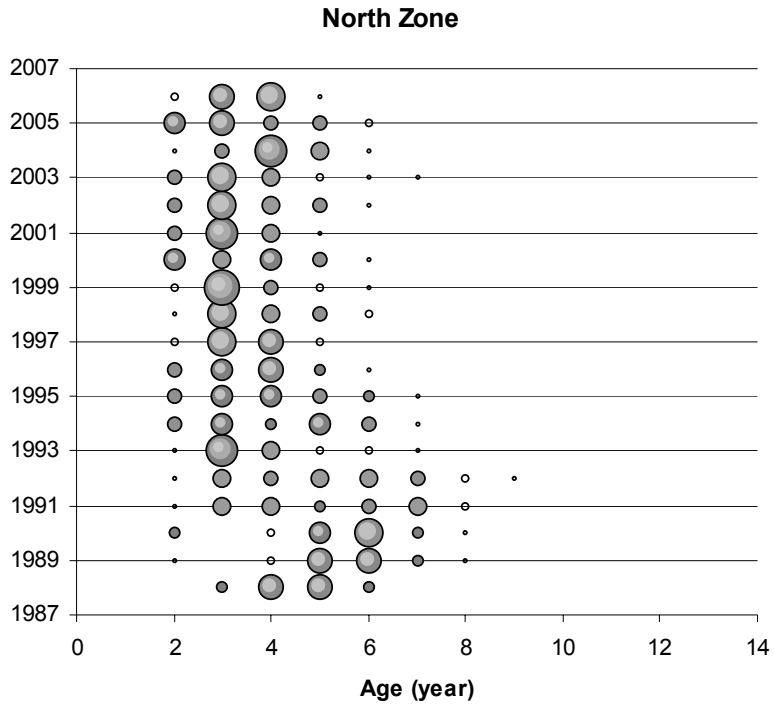


Figure 5 Age structure in specimens number of the jack mackerel catches, per macrozones.



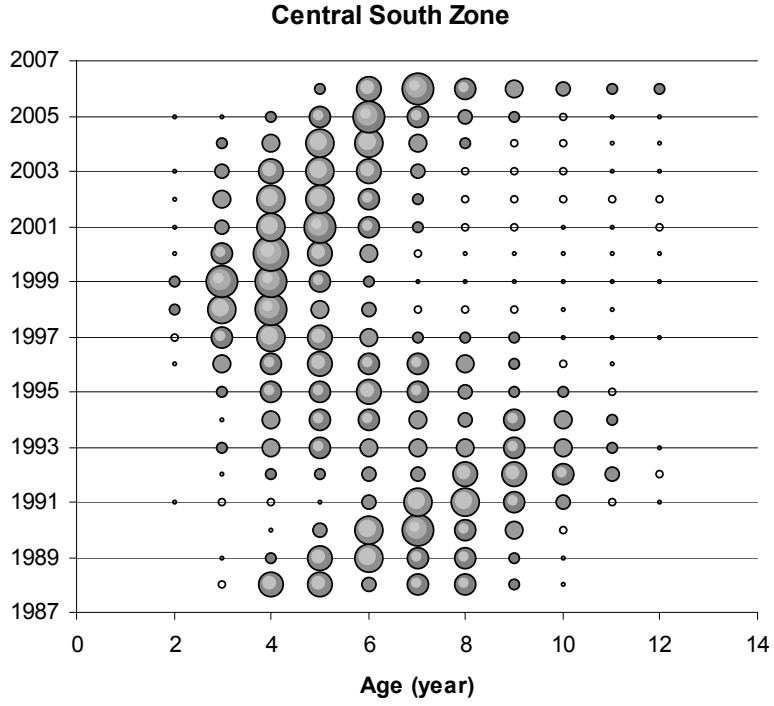


Figure 6 Bubble diagram with age proportion in the jack mackerel catches 1987 - 2006. North-Zone: zone 1 and 2; Center-South Zone : zone 3.

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