

*In Preparation***AGE AND SIZE AT MATURITY OF ALFONSINO AND IMPLICATIONS FOR THEIR MANAGEMENT IN THE SOUTHERN INDIAN OCEAN****R. Shotton**

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[<r_shotton@hotmail.com>](mailto:r_shotton@hotmail.com)**1. INTRODUCTION**

This paper is a companion paper to SIODFA Technical Report 14/01, “Yield per Recruit Analysis of Alfonsino and Implications for their Management in the Southern Indian Ocean”. This last paper addressed the issue of growth overfishing while this paper, 14/02, is intended to examine the issue of recruitment overfishing of alfonsino in the Southern Indian Ocean through harvesting of immature alfonsino.

2. AGE AND SIZE AT MATURITY

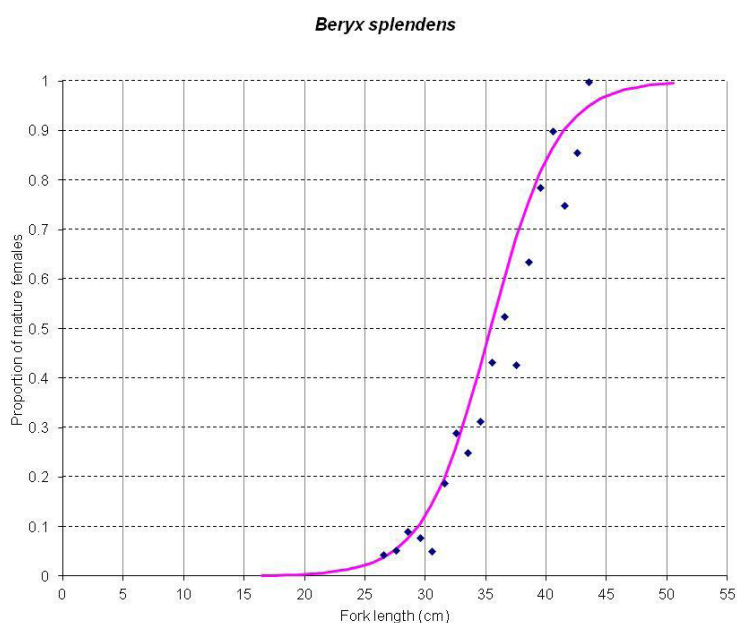
Kotlyar (1987) found that alfonsino in the Atlantic Ocean began to mature in their second year at a standard length of 19 – 20 cm and that most fish were mature by their 5th or 6th year. On Corner Rise, also in the Atlantic Ocean, sexual maturation was found to begin in their second year at a mean length of 18 cm, age of 5 - 6 years. At length 25-30 cm all fish were mature (Pshenichny *et al.* 1986, Kotlyar 1996). Vinnichenko (2012) reported that sexual maturation of alfonsino in the North Atlantic began in their second year at a mean length of 18 cm and age of 5-6 yrs: at length 25-30 cm all fish were mature. Table 6.2 lists that various $L_{50\%}$ maturity estimates obtained by different authors. (Clearly there are inconsistencies to be resolved here). Pereira & Pinho (2012) estimated mean lengths at first maturity ($L_{m50\%}$) using a logistic function. Fish were considered sexually mature if they were in gonad stages III, IV or V. This gave a mean length at $L_{m50\%}$ of 35.5 cm fork length (Figure 1). Table 1 provides a summary of findings.

Table 1
Estimates of Alfonsino $L_{50\%}$ Obtained by Different Researchers

Source	Age (50%)	Size (cm)		Comment
		M	F	
	4 – 6	~ 35		Australia
Masuzawa <i>et al.</i> (1975)		>34 cm		
Pereira & Pinho (2012)			35.5	Azores (Figure 7.vv)
Azores González <i>et al.</i> (2003)		23	23	‘Length at maturity’
Canary Islands		29.9	31.3	‘Length at maturity’

González <i>et al.</i> (2003)				
Madeira González <i>et al.</i> (2003)		30.3	34.6	'Length at maturity'
Lehodey <i>et al.</i> (1977)	7.5 (M) 5.9 (F)	34.5	33.2	
Guerrero & Arana (2009)		34.3	33.1	October 2001 to May 2003, logistic fit based on macroscopic analysis
Niklischek <i>et al.</i> (2011)		33.8		Histological analysis
Flores <i>et al.</i> (2012)	7.4 (F)	39.7	36.9	January 2006 to October 2009. Logistic fit. Macroscopic analysis.
Flores <i>et al.</i> (2012)	9.6 (F)		43.7	May to December 2001; logistic fit, histological examination
Gili <i>et al.</i> (2002)			40.4	November; logistic fit; histological examination

Figure 1
Size at Sexual Maturity (FL_{50}) for Alfonsino from the Azores
(Pereira & Pinho 2012)



The estimated size at sexual maturity at Madeira and the Canary Islands is similar - 32 and 30 cm respectively while for the Azores it was reached at 23 cm. González *et al.* (2003) summary of their information is given in Table 2.

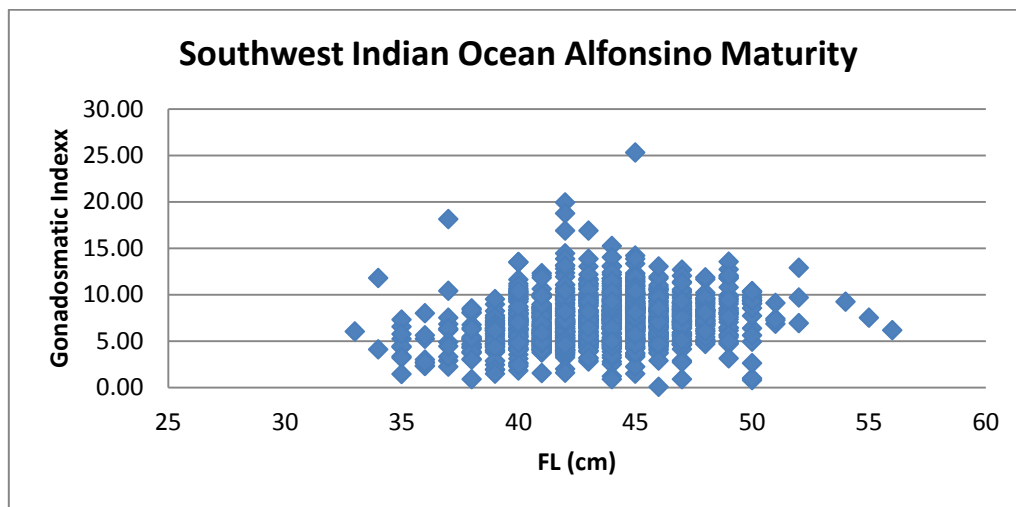
Table 2
Summary of Maturity Information for Alfonsino (González *et al.* 2003)

Location	Percentage Mature (females)	Time	$L_{50\%}$ at Maturity
Azores	54.8	Aug – March peak in Dec	23.0 both sexes
Madeira	53.0	March-June, peak Apr-May	M / F 30.3 / 34.6
Canary Islands	64.4	Feb – Nov, peak July	M / F 29.9 / 31.3

The smallest size at sexual maturity was observed in the Azores where the fishing intensity is the highest, while the biggest size at sexual maturity was found in Maderia where the fishing pressure is the lowest. However, Pereira and Pinho (2012) estimated a $L_{50\%}$ of 35.5 cm for the females using commercial samples collected from 1998 to 2011, which suggests that the estimate of González *et al.* (2003) may be biased.

Figure 2 shows the relation between the GSI for alfonsino in the Southwest Indian Ocean and length of females (G. Patchell, SIODFA, pers comm.).

Figure 2
Relation Between the GSI for Alfonsino in the Southwest Indian Ocean and Length of Females
(Patchell, SIODFA, pers. Comm.)



In Japan alfonsino begin to mature in their 2nd year and most fish are mature at 5 – 6 years (Matsuzawa *et al.* 1975). Honda *et al.* (2004) notes that in Japanese waters sexual maturation of alfonsino starts at age three or four and at a length of about 28–32 cm.

Lehodey *et al.* (1997) calculated $L_{50\%}$ using a nonlinear regression to fit a logistic function to the fish length and maturity using,

$$\frac{1}{1+A(e^{-BX})}$$

Where:

- Y = proportion of mature adults
- X = fork length
- A,B = model constants.

Lehodey Grandperrin & Marchal (1977) found that the smallest size at which the sex could be determined was 20 cm for females and 18 cm for males. The spawning stage (Stage 6 of these authors) was reached at 28 cm for females and 30 cm for males. Lehodey *et al.* (1997) found that sexual maturity could only be determined for fish collected between September and April. $F_{50\%}$ was 33.2 cm for females and 34.5 cm for males. Minimum size at pre-maturation (Stage 3) was 21 cm. The smallest pre-spawning size (Stage 5) was 26 cm for females and 30 cm for males.

In the Pacific Ocean Kotlyar (1987) found females began to mature in the first year at a standard length of 16.2 cm; males matured in their second year at a standard length of 16.3. All fish were

mature by their 6th year. In Japan Masuzawa *et al.* (1975) found that most alfonsino are mature by ages five to six.

Flores *et al.* (2012) reported that estimates of $L_{50\%}$ for the Juan Fernández Archipelago showed significant differences between sexes in both the macroscopic and histological analyses. Females matured at larger sizes and had a longer life span in comparison with males (Gili *et al.* 2002). Estimates of $L_{50\%}$ reported by Flores *et al.* (2012) were 39.67 cm for females and 36.88 cm for males based on the macroscopic analysis of the gonads. In addition, an even higher $L_{50\%}$ estimate of 43.7 cm for females was obtained using histological data, probably due to more accurate classification of maturity stage. An important factor is the average fish age at 50% maturity. Based on a deterministic transformation of the von Bertalanffy equation specifically parameterized for female *B. splendens* around the Juan Fernández Archipelago (Gili *et al.* 2002), the average age for females at 50% maturity was estimated as 7.4 years using macroscopic analysis and 9.6 years using histology. This discrepancy in age at 50% maturity could result in substantial bias in the estimates of spawning biomass obtained from stock assessment models.

Using a macroscopic maturity scale, Guerrero & Arana (2009) estimated L_{50} as 33.1 cm for females and 34.3 cm for males. For the same area, based on the histological analysis of the females' gonads, Niklitschek *et al.* (2011) reported L_{50} as 33.8 cm. These previous studies also used specimens caught by commercial vessels and thus the differences in L_{50} estimates are not thought to be caused by differences in the sampling protocols. The discrepancies found in the L_{50} maturity ogives for the Juan Fernandez area are mostly related with the visual assignment of maturity stages in the macroscopic analysis. In addition, Guerrero & Arana (2009) and Niklitschek *et al.* (2011) used the macroscopic maturity scale of Lehodey *et al.* (1997) in which fish are considered mature in stage 4 or above. Flores *et al.* (2012) considered stage 3 as the cut-off for maturity based on recent studies. In fact, preliminary histological analysis of females of *B. splendens* by Roa *et al.* (2008) suggested that the macroscopic scale of Lehodey *et al.* (1997) does not apply for *B. splendens* in Chile and they estimated L_{50} as 40 cm. This estimate is similar to the present results from the histological analysis. This similarity highlights the importance of histological analyses in determining maturity stages in the *B. splendens* inhabiting the Juan Fernandez Archipelago.

Flores *et al.* (2012) presented two fecundity ogives for alfonsino sampled from Chilean seas (Figure 4). Few females were mature before reaching a length of 30 cm and the $F_{50\%M}$ was 39.67 cm. $F_{50\%M}$ for males was nearly 3 cm smaller than for females with few fish mature before a length of approximately 26 cm.

Niklitschek & Toledo (2011) report that individuals greater than 35 cm were mature. The size at which 50% of females were mature, 33.8 cm, corresponded to an age of seven year (Figure 4)

Figure 3
Fecundity ogives for alfonsino sampled from Chilean seas (Flores *et al.* 2012)

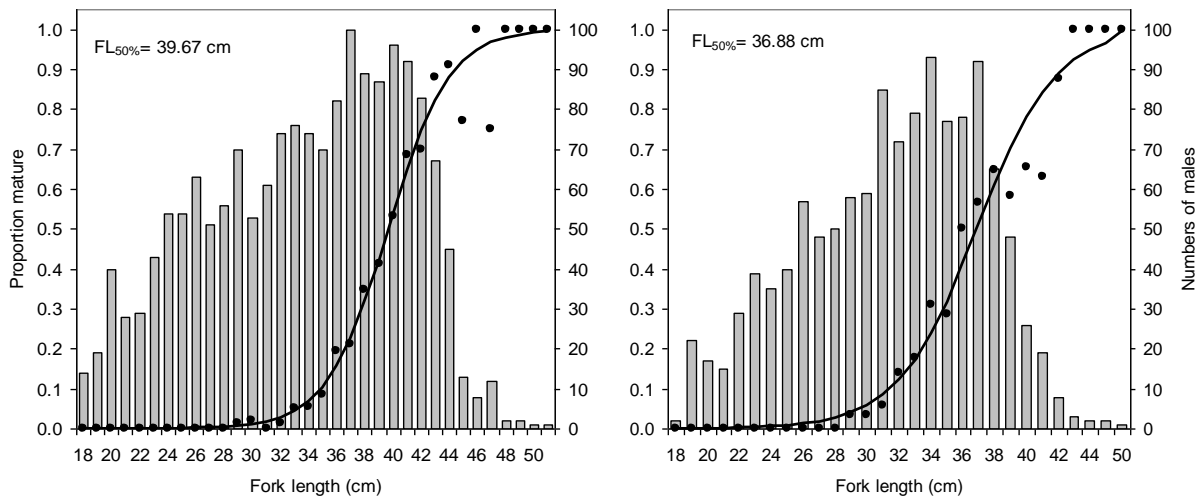
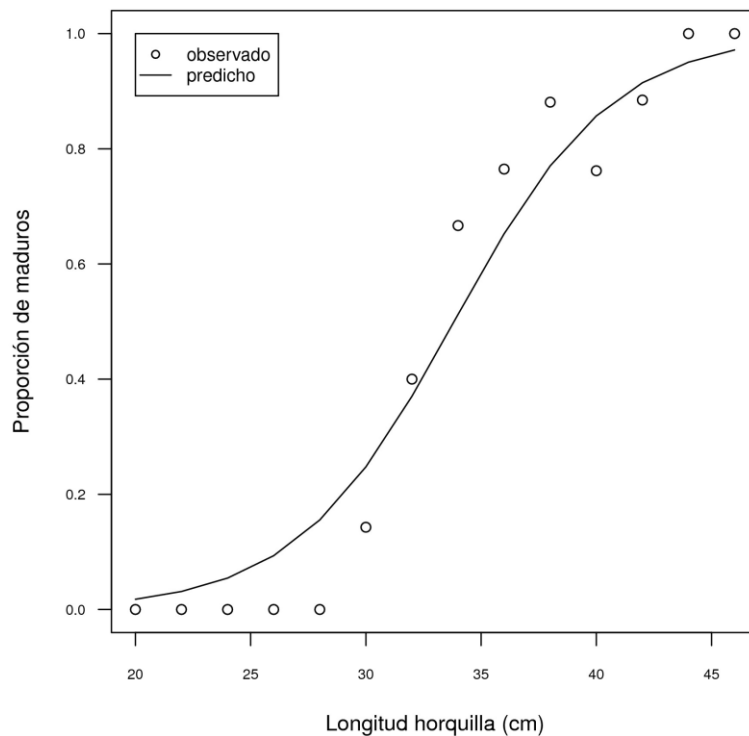


Figure 4
Logistic Ogive of Maturity versus length, females, 2010. (Niklitschek & Toledo 2011)



Related research studies conducted on alfonsino in the area of Juan Fernández Islands showed evidence of spawning in the spring season (Lamilla & Roa-Ureta 2008, *In* Roa-Ureta *et al.* 2008). The average size at sexual maturity of this species was estimated at 40 cm and about 7 - 8 years old (Roa-Ureta 2008, *in* Roa-Ureta *et al.* 2008).

Figure 5 shows the size distribution of the Chilean alfonsino catch alfonsino with the fraction of immature fish (from Tascheri *et al.* 2004) disaggregated by seamount. Figure 3.25 shows the size

frequency distribution of alfonsino catch by seamount in 2003.

Figure 5

Size distribution of the catch of alfonsino in 2003 showing the fraction of immature fish in the catch (Tascheri *et al.* 2004).

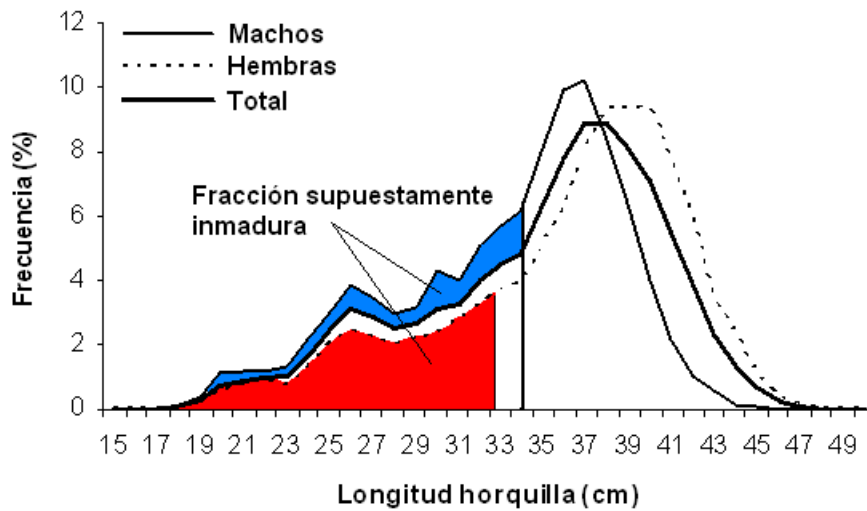
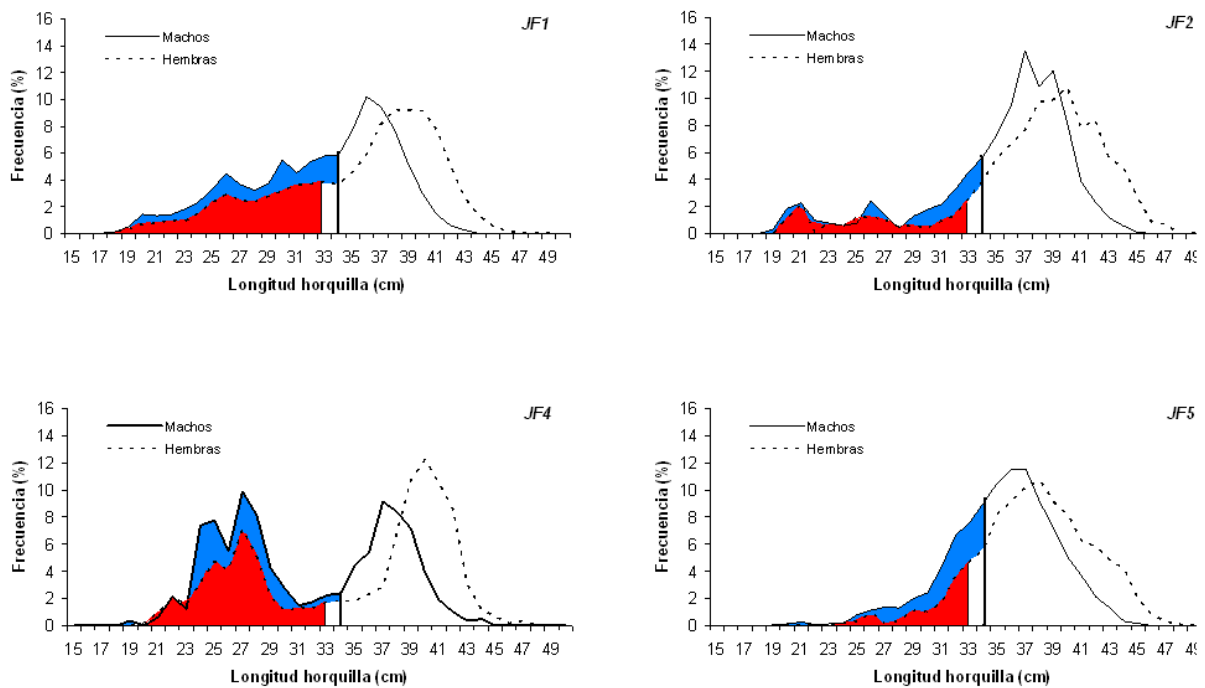


Figure 6

Size frequency distribution of alfonsino catch by seamount in 2003. (Tascheri *et al.* 2004).



3. DISCUSSION

A relevant question is whether maturation of alfonsino is primarily size dependent or age dependent,

notwithstanding the relationship between size and age. General information (I can't cite relevant studies) implies that it is more likely to be size dependent, i.e. if a fish grows rapidly because of conducive environmental conditions, it is likely to become mature at a younger age. In the absence of specific information for the Southern Indian Ocean, it is appropriate to look at results of studies undertaken elsewhere for guidance. Table 3 summarizes the information provided above, and where possible corresponding age information is provided.

Table 3
Summary of Size-Maturity Information

Area	Age (50%) years	Size (cm)	
		M	F
Australia	4 – 6	~ 35	
Japan		>34 cm	
Azores			35.5
Azores		23	23
Canary Islands		29.9	31.3
Madeira Is.		30.3	34.6
New Caledonia	7.5 (M) 5.9 (F)	34.5	33.2
Chile		34.3	33.1
Chile		33.8	
Chile	7.4 (F)	39.7	36.9
Chile	9.6 (F)		43.7
Chile			40.4

A simple minded average of the values in the last column gives a result of 34.6 cm for a $L_{50\%}$ for female alfonsino. Again, simple-mindedly, assuming an age-length relation (see SIODFA Working Document 14/01) of

$$L_{t50\%} = L_{\infty} (1 - e^{-K(t-t_0)})$$

Thus,

$$t = \frac{-\ln \left(1 - \frac{L_{t50\%}}{L_{\infty}}\right)}{K} + t_0$$

Where

- t = age at 50% maturity
- $L_{t50\%}$ = length at 50% maturity
- K = Bertalanfy growth coefficient
- t_0 = age at fish length zero (a fitting parameter),

Thus $t = 8.2$ years.

4. LITERATURE CITED

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