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Age and growth of *Pontinus kuhlii* (Bowdich, 1825) in the Canary Islands*

L.J. LÓPEZ ABELLÁN, M.T.G. SANTAMARÍA and P. CONESA

Centro Oceanográfico de Canarias, Instituto Español de Oceanografía, Carretera de San Andrés, s/n, 38120 Santa Cruz de Tenerife. España. E-mail: luis.lopez@ieo.rcanaria.es

SUMMARY: *Pontinus kuhlii* is a Scorpaenidae which forms part of the bottom longline by-catch in the Canary Islands fisheries within setting operations from 200 to 400 metres depth. Information on their biology and on the age determination and growth of the species is very scarce. The main objective of the study was to look at this biological aspect based on 421 specimens caught in the Canarian Archipelago during the period July 1996 and August 1997, 286 of which were male, 130 female and 5 indeterminate. Age was determined through the interpretation of annual growth rings of otoliths and scales, and the results fitted the von Bertalanffy growth function. Otolith sectionings were discarded due to annuli losses caused by the edge structure. The structures used in age interpretation showed numerous false rings that made the process difficult, causing 17% of the cases to be rejected. However, the age interpretations from scales showed less variability in relation to the whole otolith. The ages of the specimens ranged from 6 to 18 years for males and from 6 to 14 years for females. The growth parameters for males were: K= 0.132, L_∞ = 46.7 and t_o= 1.74; for females: K= 0.094, L_∞= 46.3 and t_o= 0.05; and for the total: K= 0.095, L_∞= 52.2 and t_o= 1.01.

Key words: age, growth, *Pontinus kuhlii*, Scorpaenidae, Canary Islands, Eastern Central Atlantic.

INTRODUCTION

The Scorpaenidae *Pontinus kuhlii* (Bowdich, 1825), commonly called offshore rockfish, is a demersal species that inhabits the rocky substratum of slope at depths that range from 100 to 460 metres (Nunes, 1974; Eschmeyer and Dempster, 1990; Franquet and Brito, 1995; Menezes, 1996). Their geographical distribution extends from the Azores Archipelago and the coast of Portugal to Angola; although their presence in the Mediterranean Sea and South African waters is uncommon (Hureau and Litvinenko, 1986; Eschmeyer and Dempster, 1990; Merella *et al.,* 1998).

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In the Canary Islands and surrounding banks, this species, although of commercial value, is part of the by-catch of the artisanal and industrial longliners whose target species is another Scorpaenidae, the bluemouth *Helicolenus dactylopterus* (Delaroche, 1809), which is a more abundant species than *P. kuhlii* in this region. These two species partially overlap their bathymetric distribution between 200 and 400 metres in the area surrounding the Canarian Archipelago, *P. kuhlii* inhabits the shallower waters.

Knowledge of the biology of this species and literature on the subject are very scarce. Isidro (1990, 1996) has contributed with data on growth and reproduction, as well as a preliminary study on management of the stock in the waters of the Azores. Krug *et al*. (1998) provided a summary of growth

TABLE 1. – Sampling for biological analysis of *P. kuhlii*. Canary Islands. Depth range: 200-400 m.

Date (month/year)	Island	n	Size range Total Length (cm)	Date (month/year)	Island	n	Size range Total Length (cm)
07/96	La Graciosa	13	26.1-43.7	02/97	Lanzarote	7	30.4-39.9
09/96	Lanzarote	38	24.3-42.7	03/97	Lanzarote	14	29.5-43.0
10/96	Lanzarote	19	21.2-41.4	03/97	Gran Canaria	14	24.9-42.0
10/96	Tenerife	1	27.2	03/97	Tenerife	18	19.6-37.2
11/96	Lanzarote	32	21.0-46.6	04/97	Fuerteventura	82	15.7-41.2
12/96	Lanzarote	27	26.1-43.8	05/97	Fuerteventura	10	17.8-46.1
01/97	Lanzarote	9	22.8-41.8	05/97	Lanzarote	16	19.8-36.0
01/97	Gran Canaria	2	37.0	06/97	Tenerife	18	22.0-40.5
02/97	Gran Canaria	3	18.0-23.2	08/97	Fuerteventura	50	20.6-42.5
02/97	Fuerteventura	48	22.4-44.1				

estimations within the same geographical area. Other authors have concentrated mainly on descriptions of new sites or revising their area of distribution. The present work aims to improve knowledge of age determination and growth of this species, and was carried out within the framework of the DG-XIV project (95/032), focused on the biology of deep-sea species covering the Macaronesian archipelagos of The Canaries, Madeira and The Azores.

Our objective includes the study of the age and growth of *P. kuhlii* from the Canary Islands Archipelago and adjacent waters. It describes the process of reading and interpreting age. Growth parameters are estimated and compared with the available results on this species (Isidro, 1996; Krug *et al.*, 1998).

MATERIAL AND METHODS

The samples used came from commercial landings obtained in ports of the Canarian Archipelago between July 1996 and August 1997 (Table 1), from ships which habitually work in these waters and surrounding areas (Fig. 1). A total of 421 individuals were used, of those 286 were male with a size range of between 17.8 and 46.6 cm in total length, 130 were female with lengths of 17.7 to 38.4 cm and 5 indeterminate (15.7-23.2 cm). In addition to the total length (mm) measuring and sex determination, otoliths were extracted from each individual and stored without any previous treatment. Cleaned scales were prepared between two slides to be stored for later observation and age determination.

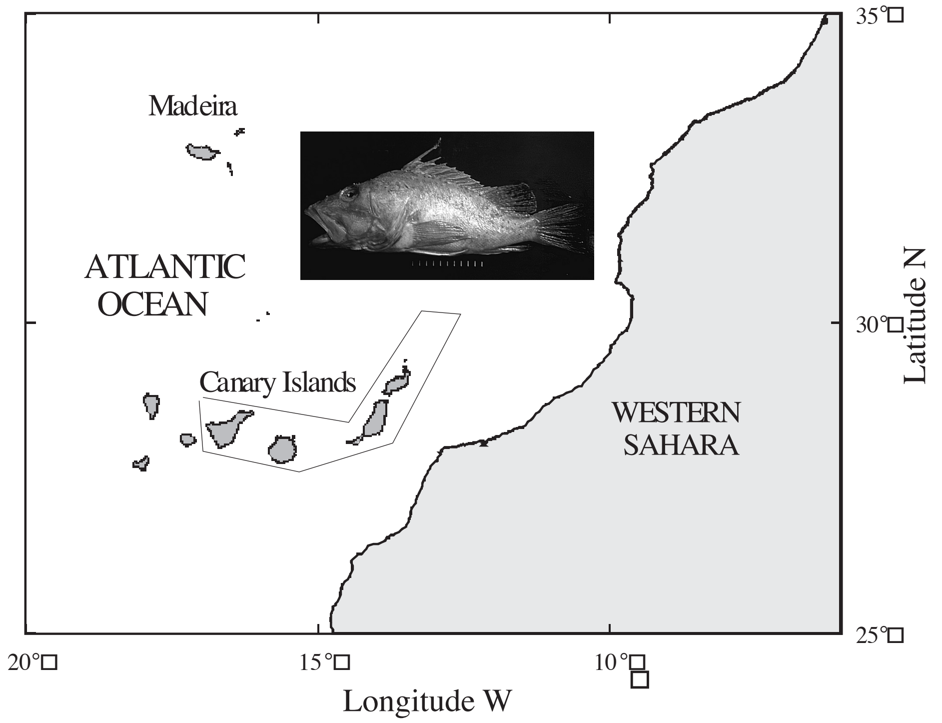

FIG. 1. – Studied species (*Pontinus kuhlii* (Bowdich, 1825)) and area where the specimens were caught.

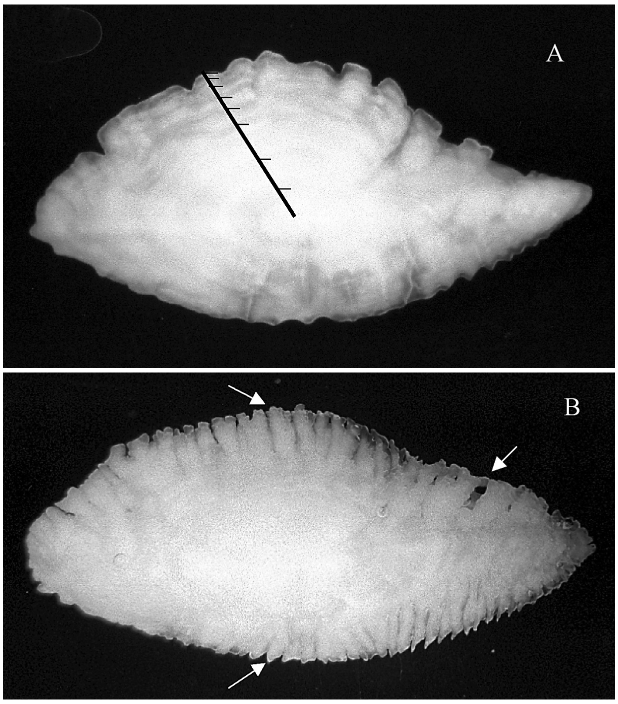

FIG. 2. – (A) *Pontinus kuhlii* otolith with 8 years assigned. The reading line shows the most common path used to identify annual rings. (B) *Pontinus kuhlii* otolith showing (arrows) edge ramifications.

Age was estimated by means of the whole sagittal otoliths (Fig. 2A) immersed in water using a stereo microscope with reflected light, and the direct reading of growth rings on scales (Fig. 3) using a profile projector. Trials with sectioned otoliths showed losses of annuli for individuals older than 10/11 years due to the great increase of crests in the sagitta edge with regard to whole otoliths in which growth rings can be identified on the crests.

The date of birth assumed was January 1st. The lack of young fish did not allow us to assess the evolution of the marginal ring in our study. However, the nature of rings were considered as annual (one hyaline and one opaque ring constitute an annual growth zone), regarding age validation on this species in the Azores (Isidro, 1996).

Readings of both structures were carried out by two people independently, and age for each specimen was adopted depending on the reliability of reading of both structures. When discrepancies occurred , a third reader intervened trying to corroborate previous observations; if this couldn't be done, the readings were rejected. The variations "*between-readers*" were analysed using the number of rings assigned to each structure and the difference between them. To determine the suitability of the method, the structures used and the precision achieved, a comparative study of the reading results from scales and otoliths of two first readers was carried out using the method by Eltink (1994). At the same time, the dispersion of individual ages assigned from scales and otoliths was analysed.

The age-length relationship was established through the corresponding keys that were elaborated in number of individuals for males and females, adopting size intervals of one centimetre and rounding off to the lower centimetre. In addition, the mean size and the standard deviation by age class was estimated taking as a reference the middle point of the interval.

The number of males, females and total of individuals in the landings was estimated at one centimetres intervals. In addition, the age-length keys were applied in order to obtain the number and percentage of individuals by sex and for the total landing, by age class.

The growth parameters for males, females and for all individuals were estimated using the least square method, fitting the length and age values to the von Bertalanffy growth function ($L_t = L_\infty\ [1\text{-e}^{\ -K(t\text{-}to)}]$) (Tomlinson and Abramson, 1961). Indeterminate individuals were assigned to males and females at 50%. Finally, a covariance analysis (Zar, 1984) was applied in order to determine if there were statistically significant differences between length and age values used to obtain the male and female growth curves, to detect differences in growth by sex.

RESULTS

Age determination

Both otoliths and scales showed many false rings (Fig. 3). The otoliths also presented numerous ram-

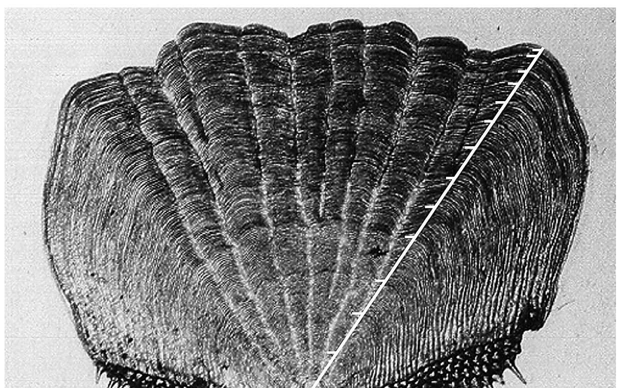

FIG. 3. – *Pontinus kuhlii* scale with 13 years assigned. The reading line shows one of the possible paths to follow to identify annual rings.

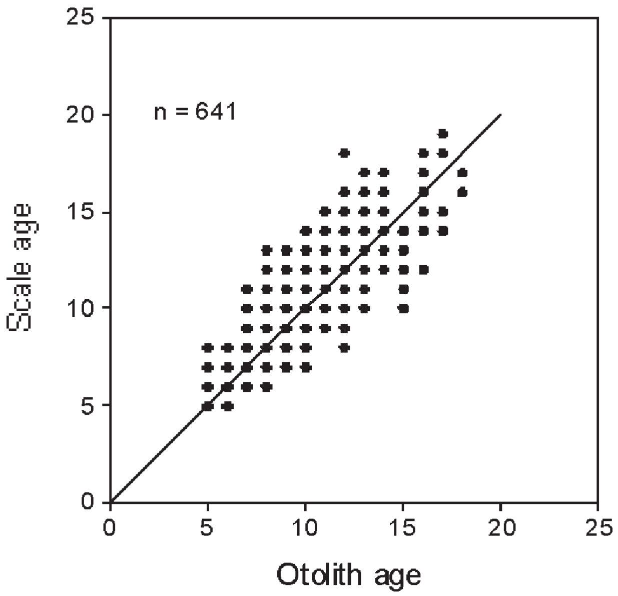

FIG. 4. – Individual age determined from scales and from otoliths. Line is scale age = otolith age.

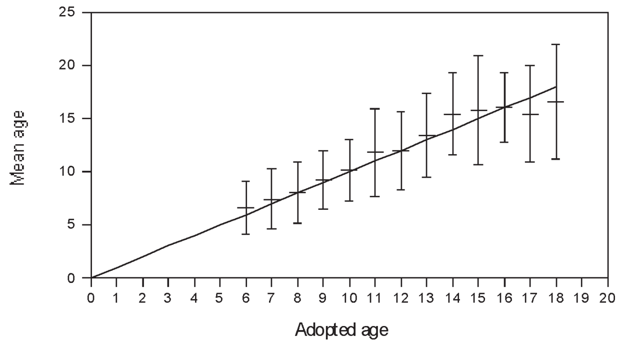

FIG. 5. – Age bias plots. The mean age recorded +/- 2stdev of all age readings (otolith and scales) is plotted against the adopted age.

ifications at the edges, adding some complexity to the process of reading (Fig. 2B). This otolith structure is common for individuals of 10/11-yrs, and the ramifications are more complex as individuals get older.

Generally, in both otoliths and scales, it was found that the ring considered as the third ring was always very visible or more easily recognised than were the first and second. On the other hand, the scale rings from the sixth or seventh to the edge are those that were identified more clearly.

Comparing the results of the first two readers in the initial phase, it was observed that they coincided in 52% of cases. After the third reader's intervention, the age assignments increased by 31%, and 17% had to be rejected.

Analysing the variations *"between-readers"*, coincidences between otolith and scales readings were 46.5% and 30.3% respectively, with frequent differences of ±1 and ±2 years. There was a tendency toward the underestimation in ages determined from otoliths in relation to ages from scales. This is also found when comparing the ages assigned by both readers to the otoliths and scales of all individuals (Fig. 4). However, no inflection takes place within the cloud of points that could indicate a differential approach in the assignment of age in scales and otoliths associated with the increase of analysed ages. This only happens at ages 15 and 18 and could be due to the scarce number of individuals analysed for these ages (12 and 2 respectively).

The comparative study of readings by structure and reader shows that the maximum precision was obtained in the scale readings (12-15% *CV*) while less precision (14-17% *CV*) was obtained in the whole otolith readings (Table 2). Variability of readings in relation to the adopted final age increases from age 10-yr (Fig. 5), but, in general the mean value is very close to the final age. The bias of this mean value, in relation to the adopted age, was not more than 1 year of difference with the exception of three ages. At ages less than 10-yrs the bias was less than 1 year.

Age-length relationship

The ages of the studied individuals ranged between 6 and 18-yrs, coinciding with the range of ages of the males. The females reached ages between 6 and 14-yrs and the indeterminate ones between 6, 7 and 8-yrs. Using age-length keys corresponding to males and females (Tables 3 and 4 respectively), the best represented age classes were included between 7 and 12-yrs. Also, the mean size for each age class of the total evolves appropriately until reaching age

TABLE 2. – CV (%) of readings and weighted mean of CV

Adopted Age	6	7	8	9	10	11	12	13	14	15	16	17	18	6-18
Reading 1 (Otolith-Reader 1)	18%	20%	20%	11%	17%	17%	17%	14%	11%	18%	10%	19%	34%	17%
Reading 2 (Scale-Reader 1)	18%	14%	16%	11%	11%	14%	10%	13%	11%	10%	5%	4%	4%	12%
Reading 3 (Otolith-Reader 2)	10%	13%	14%	19%	14%	10%	17%	18%	17%	8%	8%	0%	14%	14%
Reading 4 (Scale-Reader 2)	16%	20%	16%	17%	14%	14%	16%	12%	16%	9%	6%	11%	4%	15%

TABLE 3. – Age-length key, mean length and standard deviation. Number of males of each age class

Length / Age (cm) (yr)	6	7	8	9	10	11	12	13	14	15	16	17	18
15													
16													
17	1												
18		1											
19		1											
20	3	1	1	2									
21		1	2	1									
22	1	2	1										
23		3	2	3	1	1							
24		2	1	1	2								
25		1		1	2	1	1						
26			1	1	2	1	1						
27				2	3	3	3						
28			1	1	6	7	4						
29		1	2	2	3	2							
30				1	4	4	2	1					
31			1	5	2		3	2					
32				3	4	3	2	1	2	1			
33		1		1	1	2		1		1			
34					2	4	3			3			
35				3	4	1	2		1				
36					1		2	1	1	1	2	1	
37				1	1	2		3	4	1	3	1	
38					2	4		1	2		1	1	
39					2		1	1	3	1	1		1
40						1	2	2	5		1		
41					1		3	1	2	3		2	
42					1	1	1		2		2		1
43							2	1	1	1			
44									1			1	
45													
46								1					
Mean length (cm)	20.30	23.79	25.25	29.11	31.64	32.12	34.09	37.44	39.21	37.58	38.90	40.00	41.00
(SD, cm)	1.8	3.9	3.7	4.8	4.8	4.6	5.6	4.6	3.0	3.8	2.3	3.0	2.1
N	5	14	12	28	44	37	32	16	24	12	10	6	2

classes 13 and 14, in those an increment that could be considered anomalous takes place.

Size and age composition of catches

In Figure 6 the size distributions of catches (that coincides with the analysed individuals) are presented for males, females and indeterminates. The lower limit in both for males and for females was 17 cm. However, males reached a maximum much larger than that of the females (46.0 cm and 38.0 cm respectively).

The transformation of these size distributions into ages (Table 5) shows that males are better represented at age classes 10, 11 and 12-yrs (13%-18%), followed by 9-yr (11.5%) and 14-yrs (10.4%). As for females the ages better represented were equally the 10-yr (22%), 8-yrs (19.5%) and 9-yrs (17%). In general, considering the total of individuals, the majority of individuals caught and analysed reached ages included between 9 and 12 years, and 19% of the total were 10-yrs.

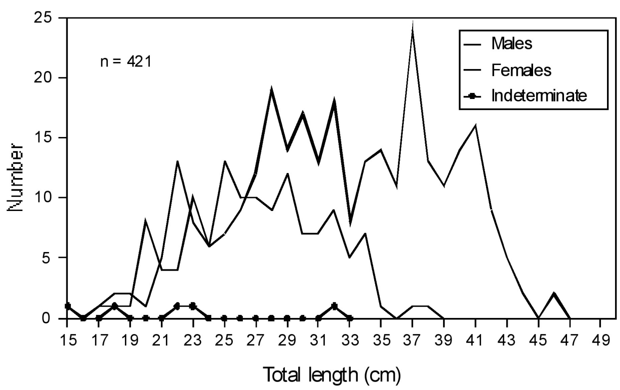

FIG. 6. – Length frequency distribution by sex of the total individuals analysed.

Growth

The parameters that define the growth of *P. kuhlii* by sex and for the total of individuals as well as the number of individuals used and the range of sizes are presented in Table 6. The annual *K* esti-

TABLE 4. – Age-length key, mean length and standard deviation. Number of females of each age class

Length (cm) / Age (yr)	6	7	8	9	10	11	12	13	14	15	16	17	18
15	1												
16													
17	1												
18		2			1								
19			1										
20				1									
21		3	1										
22		2	4	4	3								
23		1	3			1	1						
24		1	1		3								
25		1	3	2	4	1	1						
26		1	1	4	2		1						
27			3	4	2								
28			1		1	2							
29			1	1	6	1	1						
30			1	1	3	1							
31			1	1		1		1					
32						4	1		1				
33				1		1	1						
34				1	1		5						
35							1						
36													
37						1							
38									1				
39													
40													
41													
42													
43													
44													
45													
46													
Mean length (cm)	16.50	22.41	25.31	26.85	26.96	30.65	31.58	31.50	35.50				
(SD, cm)	1.4	2.5	3.2	3.7	3.4	3.6	4.2	-	4.2				
N	2	11	21	20	26	13	12	1	2				

TABLE 5. – Age composition of catches of *P. kuhlii* by sex and total

Age class	6	7	8	9	10	11	12	13	14	15	16	17	18
Males	5	17	13	33	52	44	37	20	30	14	13	8	2
%	1.7	5.9	4.5	11.5	18.1	15.3	12.8	6.9	10.4	4.9	4.5	2.8	0.7
Females	2	14	26	23	29	20	14	2	3				
%	1.5	10.5	19.5	17.3	21.8	15.0	10.5	1.5	2.3	-	-	-	-
Total	7	31	39	56	81	64	51	22	33	14	13	8	2
%	1.7	7.4	9.3	13.3	19.2	15.2	12.1	5.2	7.8	3.3	3.1	1.9	0.5

mated varied between 0.094 and 0.132 and the L_∞ between 46.3 and 52.2 cm. The growth curves including the size ranges, the mean values of the observations and their confidence limits, for males, females and the total of individuals, are presented in figures 7, 8 and 9 respectively. Males show a superior *K* to that of the females but the L_∞ is very similar. The growth parameters of the combined curve were: L_∞ (52.2 cm, 6.7 *SE*) and the *K* (0.095 cm, 0.031 *SE*).

Lengths corresponding to the fitted curves do not move away from mean lengths of the individuals for

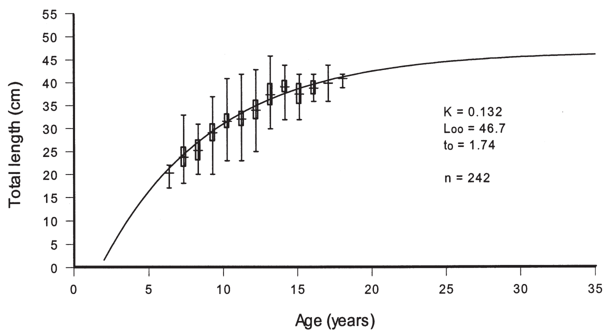

FIG. 7. – Growth curve of *Pontinus kuhlii* males. Vertical lines represent length range observed and bars indicate mean +/- 2SE.

TABLE 6. – Estimated parameters of von Bertalanffy growth equation of *P. kuhlii* in the current and other studies, size range and number of specimens (O: otolith reading; S: scale reading; M: males; F: females; T: total; n: number of individuals; TL: total length; L_∞: asymptotic length, K: growth coefficient, t_0: theoretical age when length is zero).

Source/Area	Method	Sex	n	Size range TL (cm)	L_∞ (cm)	K (yr^{-1})	t_0
Current study	O+S	M	242	17.80 - 46.60	46.7	0.132	1.74
(Canary Islands)	O+S	F	108	15.70 - 38.40	46.3	0.094	0.05
	O+S	T	350	15.70 - 46.60	52.2	0.095	1.01
Isidro (1996)	O	M	367	14.50 - 49.50	54.2	0.076	-1.96
(Azores)	Back-calculation				55.8	0.092	-5.58
	O	F	269	14.50 - 40.50	38.2	0.120	-1.73
	Back-calculation				46.0	0.115	-5.72
	O	T	662	13.50 - 49.50	51.7	0.076	-2.10
	Back-calculation				54.4	0.093	-5.58
Krug *et al.* (1998)	O	M	402	-	80.2	0.037	-3.82
(Azores)	O	F	396	-	43.3	0.096	-1.98
	O	T	824	-	73.6	0.039	-3.87
	MULTIFAN	T	1171	-	51.4	0.106	-0.55

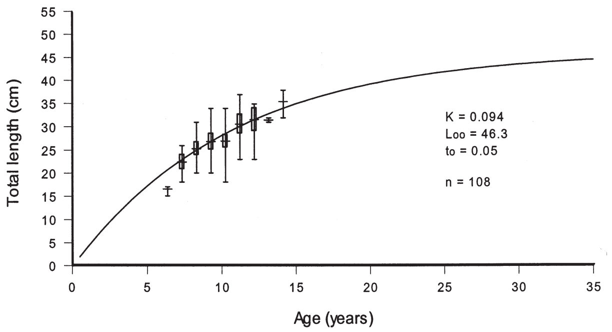

FIG. 8. – Growth curve of *Pontinus kuhlii* females. Vertical lines represent length range observed and bars indicate mean +/- 2SE.

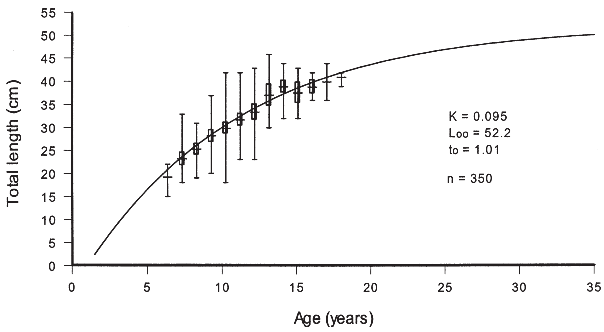

FIG. 9. – Growth curve of *Pontinus kuhlii* for males and females. Vertical lines represent length range observed and bars indicate mean +/- 2SE.

age class that evolve with gradual increments until age 13-yrs, when some fluctuations take place above and below the growth curve. The standard error of mean sizes decreases considerably when considering all the data as a whole (Fig. 9) and consequently the confidence limits are affected in the same way.

The covariance analysis showed that there are statistically significant differences (P <0,05) between the size-age relationship of females and that of males.

DISCUSSION

The difficulties found in the current work in relation to the age interpretation of *P. kuhlii* were also shown by Isidro (1996) working with otoliths of this species caught in the Azores, establishing that 36% of these were difficult to read or illegible. In the Canaries that difficulty would be located at around 48%, with the interpretation problems growing from the age of 10-yr.

The tendency to underestimate age from otoliths could be due to a systematic error in the interpretation of rings/false-rings in each of the structures; to the presence of irregular edges in otoliths starting from a certain age that hinders their interpretation; or probably to the greater ease with which growth rings in the scales are detected, mainly from the sixth or seventh ring to the edge.

Regarding the results obtained, just as other authors found for this and other species of the same family, and despite the complex reading process of both structures, everything seems to indicate that these are valid for the determination of age in the current case, which is not so in other species whose scales are rejected (Bergstad, 1990). Beamish and Mcfarlane (1987) do not recommend the use of scales in age determination because of the underestimation of ages of older fish. However, in the case of *P. kuhlii*, scales not only provide valid complementary information for the assignment of age, but in the case that it were necessary to choose only a single structure to determine age, there is no reason it should not be the scale. Likewise, the use of whole otoliths in spite of difficulties with readings, could be justified taking into account that sectioned otoliths lose annuli in the major axis because of the edge ramifications and growth rings in minor axis are difficult to identify at the outer margin. The use of whole otoliths in age determination is closely related to species, as could be concluded from the study done by Maceina and Betsill (1987), although longevity makes this more difficult.

Considering both structures for age determination in this species, the analysis of the bias in the observations has shown an increase in the variability of the mean values in relation to the final age adopted as early as 10-yrs. This could be due to the difficulty in the interpretation of age from otolith because of the ramification of their edges. Also, the positive difference in most cases between the mean and the adopted age could be due to the greater number of rings detected in the scales in relation to the otoliths. This means that, the adopted final age apart, the value of the average of the readings tends to be the same or superior to it. Whichever the case, the scarce difference between the average of the readings and the adopted final age (less than 1 year in most cases), shows the coherent system of age interpretation applied by the reading team considering the results obtained.

Isidro (1996) reported for *P. kuhlii* an age range of 2/18-yrs corresponding to 13.5/47.5 cm of total length, which is very similar to ages 6/18-yrs corresponding to 15.7/46.6 cm of total length found in this study. Thus, results on age determination and those related to the different fittings carried out seem to be within limits that can be considered acceptable and they indicate that *P. kuhlii* is a fish with slow growth. However, in all cases and especially in that of the females, principally due to hook selectivity and accessibility to the resource, a shortage of individuals in the 15-yrs age class and an absence of young specimens in ages below 6-yrs is observed. Consequently, the theoretical growth curve lacks size-age pairs of values of reference in the initial and end sections. Considering these factors, and in spite of indications or evidence that there is differential growth between sexes and uncertainties associated to the fitting carried out by sex, the use of the parameters of the total equation is advisable.

The results obtained for all individuals are of the same order as the estimates made by Isidro (1996) for *P. kuhlii* in Azores waters (Table 6), mainly from values of back-calculation (K= 0.095, 0.093 and L_∞ = 52.2, 54.4, respectively). The estimations of Krug *et al*. (1998) show a great variability, although there is some agreement with the current study for females (otolith reading) and for the total (MULTIFAN).

Comparing these results with those of other species of the Scorpaenidae family like the previously mentioned *Helicolenus dactylopterus*, which overlaps in habitat with the target species of this study, it is observed in Kelly *et al*. (1999) that although they reach an inferior asymptotic length (males 37.2 cm, females 31 cm), the growth constants (0.06 - 0.09) are similar to those estimated for *P. kuhlii* in the current work. Similar values for the growth constants (between 0.09 and 0.18) were found by Isidro (1987), Ragonese and Reale (1992), D'Onghia *et al*. (1996), Esteves (1997), Krug *et al*. (1998) and Massuti *et al*. (2000). White *et al*. (1998) also found, for this species, that males grow faster and are more abundant than females: this is so with *P. kuhlii*.

In species of the genus *Sebastes* (Love *et al*., 1990), it is observed in general, that these also have a low K, close to that of *P. kuhlii*, but on the other hand, it is the females that reach a larger asymptotic size. The K values estimated by other authors for *Sebastes* spp. ranged between 0.04 and 0.30 (Phillips, 1964; Lenarz, 1980; Archibald *et al.,* 1981; Nelson and Quinn, 1986; Wilkins and Weinberg, 1986 and Pearson *et al*., 1991). Although comparison with other species of the same family does not suppose a conclusive confirmation of the results obtained, this still indicates that the values obtained in the current study are not so far removed from hypothetical values expected.

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