AGE AND GROWTH OF THE SOUTH AMERICAN SEA LION, *OTARIA FLAVESCENS* (SHAW, 1800), IN SOUTHERN BRAZIL

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From 1977 to 1986, skulls and teeth of the South American sea lion, *Otaria flavescens*, found dead along 262 km of beaches of the southern coast of Brazil, between latitudes 31°51′S and 33°40′S, were collected for aging. Cranial sutures were examined in 126 skulls, and growth-layer groups were counted in longitudinally bisectioned canines of 175 specimens. Based on a known-age specimen, growth-layer groups were found to be formed annually. A high correlation was found between the ages estimated from teeth and those estimated by suture closure. The oldest males and females were 16 and 14 years, respectively. Ages 3–5 years were the most frequent. The Bertalanffy growth parameters adjusted with the Marquardt's algorithm were L_∞ = 254.4 cm, K = 0.305, t_0 = −1.6 years for males, and L_∞ = 194.4 cm, K = 0.306, t_0 = −2.0 years for females. Ninety-five percent of the maximum length is attained by 8 years of age for both sexes.

Key words: ***Otaria flavescens*, aging, growth, Brazil**

The South American sea lion, *Otaria flavescens* (Shaw, 1800) [*O. byronia*, de Blainville, 1820], occurs in temperate waters of South America from 4°S latitude in the Pacific Ocean, rounding the southern tip of the continent, to 23°S in the Atlantic Ocean (Vaz-Ferreira, 1982), but occasionally is reported as far north as 13°S on the Atlantic side (Castello, 1984). It is the most common pinniped in southern Brazil, and the specimens found along Rio Grande do Sul are reported to be part of the stock that reproduces on Uruguayan rookeries during the austral summer (Pinedo, 1986). Large numbers of sea lions occur in southern Brazil, mainly during the winter and spring seasons (Pinedo, 1986; Rosas, 1989).

Age and growth of *O. flavescens* from the Falkland/Malvinas Islands were studied by Hamilton (1934, 1939), using external morphology, color, and osteologic development. Later, Laws (1962) examined teeth of specimens from the same islands and suggested an annual periodicity in the deposition of dentine growth layers. Sea lions from the Patagonian coast of Argentina were aged from their teeth by Ximenez (1976), Lewis and Ximenez (1983), and Crespo (1988). In this paper the age of sea lions from southern Brazil was estimated based on growth-layer groups present in the dentine.

MATERIALS AND METHODS

The skulls of dead sea lions found along 262 km of beach in southern Brazil, from Barra do Estreito (31°51′S) to Hermenegildo (33°40′S), in the state of Rio Grande do Sul, were regularly collected from 1977 to 1986. Also, the tooth of a captive male sea lion of known age was examined after its natural death, and growth-layer groups were counted.

The standard length of body (SL) was measured according to the Committee on Marine Mammals (1967). After collection, the heads were buried for ≤3 months. The skulls were later boiled to eliminate the remaining fat and flesh, and expose the sutures.

The condylobasal length (CBL), zygomatic width (ZW), rostral width (RW), mandibular

TABLE 1.—*Mean suture-age indices of male and female* Otaria flavescens *in southern Brazil and Falkland/Malvinas Islands in relation to ages. Numbers in parentheses denote numbers of skulls examined.*

Age (years)	Southern Brazil (this paper)		Malvinas/ Falkland Islands (Sivertsen, 1954)	
	Males	Females	Males	Females
0	9.2 (4)	9.5 (2)	9.4 (14)	9.1 (6)
1	12.5 (3)	11.5 (2)	10.6 (11)	10.7 (3)
2	13.5 (6)		13.2 (5)	12.5 (4)
3	15.1 (15)	14.2 (5)	15.0 (5)	14.3 (14)
4	16.5 (15)	15.4 (5)	17.2 (5)	15.0 (22)
5+	24.1 (51)	23.7 (18)	24.6 (22)	20.6 (57)
5	19.2 (17)	17.7 (3)		
6	20.1 (7)	20.5 (2)		
7	24.7 (9)	22.7 (3)		
8	25.0 (3)	27.0 (2)		
9	26.5 (2)			
10	28.0 (3)	26.0 (3)		
11	30.5 (2)			
12	30.5 (2)	27.0 (2)		
13	33.0 (2)	24.0 (2)		
14	34.0 (3)	31.0 (1)		
15				
16	36.0 (1)			

length (ML), and mandibular width (MW) were measured to 0.1 mm using a caliper. Sex of each specimen was determined from external characteristics or by the rostral and mandibular indices (RW/CBL and MW/ML, respectively) and by the angle of the canine crowns, according to Crespo (1984). Nine cranial sutures mentioned by Sivertsen (1954) were used to estimate the relative ages: (1) occipito-parietal, (2) squamoso-parietal, (3) interparietal, (4) interfrontal, (5) coronal, (6) basioccipito-basisphenoid, (7) maxillary, (8) basisphenoid-presphenoid, and (9) premaxillary-maxillary. Each of these sutures was ranked according to degree of closure, giving the following indices: 1 for open, 2 for less than one-half closed, 3 for more than one-half closed, and 4 for completely closed (Sivertsen, 1954). Therefore, the minimum suture age expressed by these indices is 9, when all cranial sutures are completely open, and the maximum index is 36 when all are totally closed. Suture ages were calculated for 94 males and 32 females.

Ages were estimated from the canines of 133 males and 41 females (and from an incisor of a male lacking canines), according to Pierce and Kajimura (1980), with the following modifications. The teeth were left in water for 10 days, then cleaned with a brush. They were bisectioned longitudinally with a metal handsaw and polished with 100–600 grit sandpaper and decalcified in a solution of 5% formic acid. Teeth of young males and females were left in the solution for 3 h and those of adult males for 5 h. They were later washed in running water for 5 h and air dried.

Dentine layers with different degrees of mineralization appeared as ridges and valleys. Graphite powder was used to highlight the ridge-and-valley groupings resulting in alternating dark-and-pale coloring. Each pair of dark-and-pale bands (one growth-layer group) was assumed to correspond to 1 year of life.

Since the dentine of older animals usually is difficult to read because the teeth are worn, the growth layers in the cementum of canines of males >13 years and of females >9 years also were counted. Two readings were performed on each sectioned tooth, with a minimum interval of 3 months. In 18% of the cases, the second reading differed from the first and the teeth were examined a third time. The most frequent value was used as the age of the animal.

The Bertalanffy growth parameters calculated were: t_0, hypothetical age at which the sea lion would have been zero length if it had always grown in the manner described by the equation; L_∞, asymptotic length (i.e., average length the sea lions would reach if they were to grow indefinitely); and K, growth constant. These parameters were obtained from the teeth ages by using the FISHPARM program (Seila et al., 1988), which implements the Marquardt algorithm for non-linear least-square parameter estimations.

RESULTS

Periodicity of layer formation was confirmed by comparison with a tooth from a live specimen found on the beach in August 1975 when it was assumed to have been 8–9 months of age. This animal was kept in a pool in the Rio Grande Oceanographic Museum until its natural death 10 years and 9 months later, in May 1986. The canine of this specimen showed 12 dark and 11 pale

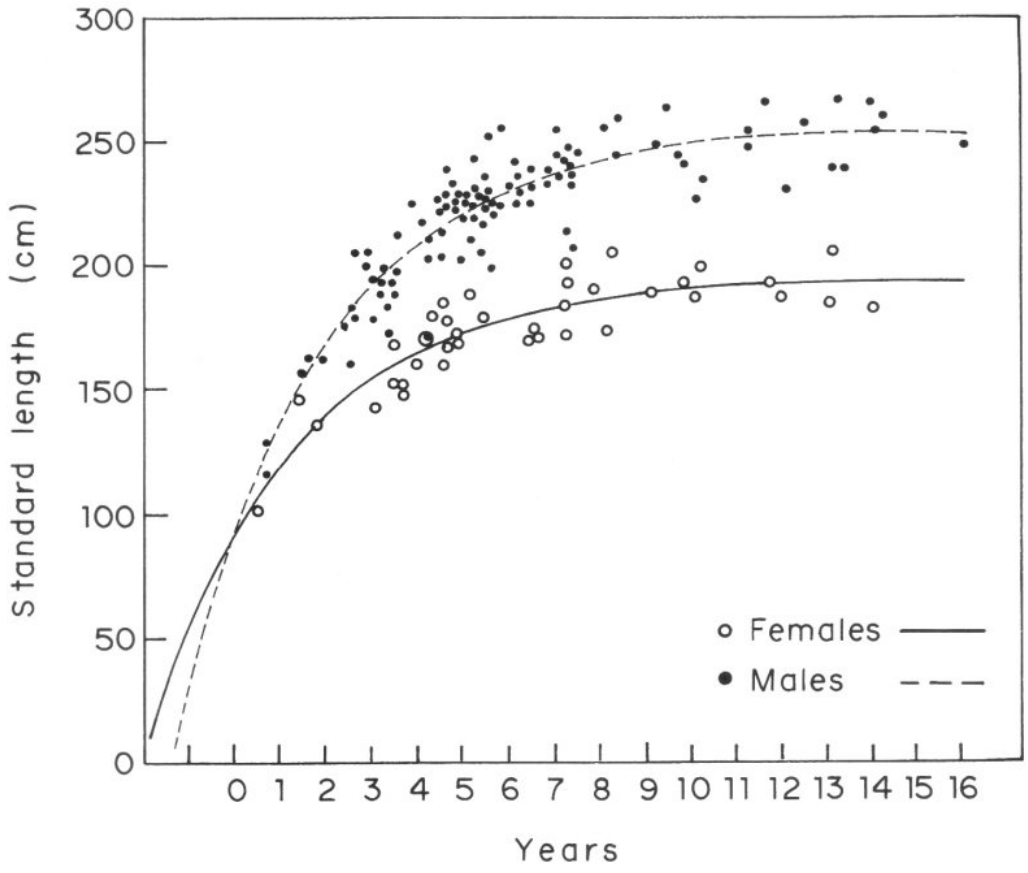

FIG. 1.—Growth curves for standard length of body in male and female *Otaria flavescens* in southern Brazil.

layers, confirming the annual deposition of each pair of layers.

Mean suture-ages (SA) ranged from 9.2 to 36 in males and 9.5 to 31 in females (Table 1). These indices showed a highly significant correlation with tooth ages (TA). The linear-regression equations obtained were SA = 10.07 + 1.97 TA (r = 0.9535, n = 94) for males, and SA = 10.58 + 1.43 TA (r = 0.9161, n = 32) for females.

A highly significant linear correlation was found between condylobasal length (CBL) and standard length of body (SL) for both sexes: SL = −76.42 + 9.50 CBL (r = 0.908, n = 38) for males, and SL = −69.23 + 9.36 CBL (r = 0.930, n = 17) for females. These relations are useful for estimating the standard length in incomplete or deteriorated specimens.

The number of males and females by age and length intervals of 10 cm (length-age keys), and the mean lengths per age are shown in Table 2. The maximum-observed length for males was 266 cm and for females 204 cm. The maximum age for males was 16 years and for females 14 years. Males grew faster than females and both sexes attained, on average, 95% maximum length at ca. 8 years of age (Fig. 1).

The Bertalanffy growth parameters were calculated for ages estimated in months from the growth-layer groups counted. For these calculations, all specimens were assumed to have originated from the Uruguayan rookeries (Pinedo, 1986). The first of February was chosen as being the birth date of the sea-lion young because births are reported to occur there from December to February (Vaz-Ferreira, 1981). Parameters obtained for males were L_∞ = 254.4 cm, K = 0.305, t_0 = −1.60 years, and for females L_∞ = 194.4 cm, K = 0.306, t_0 = −2.00 years.

TABLE 2.—*Length-age key of male and female* Otaria flavescens *from southern Brazil. SL = mean standard length. Values in field of table indicate number of specimens for each combination of age and standard length.*

Standard length (cm)	Age (years)																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Males																	
110–119	1																
120–129	1																
130–139																	
140–149																	
150–159		2															
160–169		1	2														
170–179			1	2	1												
180–189			2	3													
190–199				9		1											
200–209			1	3	7	3											
210–219				1	3	1		1									
220–229					5	8	2	1			1						
230–239					1	5	4	4			1		1	2			
240–249						1	1	4	1	1	2	1					1
250–259						1	1		2			1		1	2		
260–266										1			1	1	1		
n	2	3	6	18	17	20	8	10	3	2	4	2	2	4	3		1
SL	122.5	159.3	177.6	193.3	212.6	224.7	235.8	235.7	252.6	255.5	235.7	249.5	247.5	249.5	256.5		248.0

TABLE 2.—*Continued.*

Standard length (cm)	Age (years)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Females																	
100–109	1																
110–119																	
120–129																	
130–139		1															
140–149		1		2													
150–159				2													
160–169				1	4												
170–179					2	2	2	1	1								
180–189						1		1		1	1		1	1	1		
190–199								1	1		2		1				
200–204								1	1					1			
n	1	2		5	6	3	2	4	3	1	3		2	2	1		
SL	102.2	140.5	148.2[a]	152.2	167.3	178.7	172.0	187.2	189.7	189.0	192.3		189.0	194.0	181.0		

[a] Mean length calculated by using an increase of 5.5% in total length between the 1st and 2nd years, according to Hamilton (1934).

Discussion

The half-sectioned preparations of canines proved useful for estimating the ages of *O. flavescens,* and were easier to prepare than thin sections. Nevertheless, the latter are better for recognizing the terminal layers which, however, are not essential for estimating age structure of a population.

Tooth and suture-age relations were similar to those estimated by Sivertsen (1954) between animals of known age and suture-age indices (Table 1). However, the rapid suture-age transition stated by Sivertsen (1954) between ages 4 and 5+ years was not confirmed when the ages were ungrouped (Table 1). The strong correlation observed between the suture indices of skulls and tooth age in years, as well as the fact that the former is less time-consuming, suggest that suture indices can be used as an alternative method or when teeth are not available for aging the South American sea lion.

Pierce and Kajimura (1980) suggested that the differences in mineralization of dentine layers in pinniped teeth are due to poor feeding during reproductive periods. The tooth of the captive sea lion we sampled showed well-differentiated layers with a similar pattern to those of wild sea lions. However, since it was regularly fed all year, other mechanisms acting on metabolism must participate in the control of dentine deposition.

The maximum recorded length of male and female *O. flavescens* from Falkland/Malvinas Islands was 256.4 and 195.6 cm, respectively (Hamilton, 1934, 1939). The maximum-length data obtained by Vaz-Ferreira (1982) for specimens in Uruguay were 245 cm for males and 200 cm for females. The specimens observed in Rio Grande do Sul had greater total lengths, with the largest male measuring 266 cm and the largest female 204 cm. The differences, however, could be due to variation in the measuring method, since the criteria used for measuring specimens in Uruguay and Falkland/Malvinas Islands is unknown.

Acknowledgments

This study was partly financed by Conselho de Desenvolvimento Científico e Tecnológico (CNPq) and Fundação de Amparo a Pesquisa do Rio Grande do Sul (FAPERGS). We thank E. C. Rios, the director of the Rio Grande Oceanographic Museum, for permission to examine the tooth of the sea lion that died in captivity, and K. K. Lehti for reviewing the manuscript. The first author received a grant from the Coordenação de Aperfeiçoamento de Pessoal de Ensino Superior (CAPES).

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Submitted 4 October 1991. Accepted 4 March 1992.

Associate Editor was Kenneth T. Wilkins.