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Age and growth of some delphinids in south-eastern Brazil

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This study provides the first compilation on age and growth of some delphinids in south-eastern Brazil (18°25'S–25°45'S). A total of 154 delphinids were reported: 44 Atlantic spotted dolphin *Stenella frontalis*; 36 bottlenose dolphin *Tursiops truncatus*; 26 'Brazilian' common dolphin *Delphinus* sp.; 20 rough-toothed dolphin *Steno bredanensis*; 16 Fraser's dolphin *Lagenodelphis hosei*; 3 false killer whale *Pseudorca crassidens*; 3 unidentified *Stenella* sp.; 2 pantropical spotted dolphin *Stenella attenuata*; 2 short-finned pilot whale *Globicephala macrorhynchus*; 1 spinner dolphin *Stenella longirostris;* and 1 striped dolphin *Stenella coeruleoalba*. Age was estimated by counting the number of growth layer groups present in the dentine in 74.5% of the sample. The growth of 92 individuals of the first five species was determined by the Gompertz model to length-at-age data. *Stenella frontalis*—the oldest specimen was 23 y and the asymptotic length of 224.4 cm predicted by growth curve occurred at about 20 y; *T. truncatus*—the oldest specimen was 26 y and the asymptotic length of 301.3 cm predicted by growth curve occurred at about 20 y; *Delphinus* sp.—the oldest dolphin was 18 y and the asymptotic length of 215.9 cm predicted by growth curve occurred at about 5–6 y; *S. bredanensis*—the oldest specimen was 24 y and the asymptotic length of 258.1 cm predicted by growth curve occurred at about 10 y; *L. hosei*—the oldest specimen was 19 y and the asymptotic length of 231.2 cm predicted by growth curve occurred at about 7–8 y. Only age was estimated for the other species. The age-at-length data for *S. frontalis*, *Delphinus* sp., *S. bredanensis* and *L. hosei* were consistent, suggesting a good agreement with previous work on these species. For *T. truncatus*, the age at asymptotic length obtained in this study might be confirmed by increasing the sample size. The information currently presented will contribute to further life history research of delphinids on the western south Atlantic coast.

INTRODUCTION

The knowledge on age and growth data is relevant to estimation of parameters used in stock assessment and management (Perrin & Reilly, 1984). The age of delphinids has been estimated by counting the growth layer groups (GLGs) in dentine or cementum. GLGs is a generic term and it is used to define groups of incremental growth layers. Increments of tissue are deposited in teeth as a function of time and GLGs may be recognized due to the cyclic repetition (Hohn & Hammond, 1985; Perrin & Myrick, 1980; Chivers & Myrick, 1993). The accumulation of layers was reported to be annual in specimens of bottlenose dolphins *Tursiops truncatus* born and deceased while in captivity (Sergeant, 1959; Sergeant et al., 1973). The one-GLG-per-year model has also been suggested for other closely-related delphinids, including long-finned pilot whale *Globicephala melas*, striped dolphin *Stenella coeruleoalba* and pantropical spotted dolphin *Stenella attenuata* (Kasuya, 1972; Kasuya et al., 1974; Perrin et al., 1976).

For most species of cetaceans direct calibration of teeth used for age estimation is not possible because of the difficulty in obtaining known-age or marked specimens (Pinedo & Hohn, 2000). Hohn et al. (1989) suggest that an alternative approach to helping ensure accurate and precise age estimates is to use information on growth-layer patterns from other species where growth layers have been calibrated, since at least within taxonomic groups, e.g. the delphinids, growth layers retain many similarities (Hohn, 1990; Perrin & Myrick, 1980).

There have been few studies on age and growth of the delphinids on the western south Atlantic coast. The biological aspects of the estuarine dolphin *Sotalia guianensis*

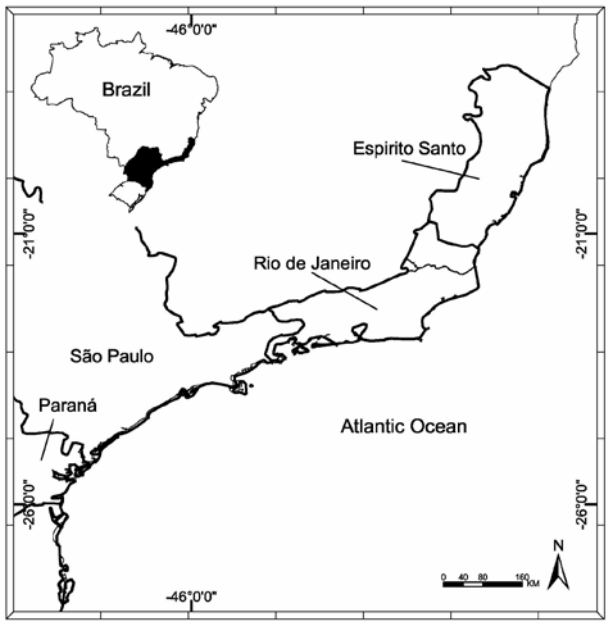

Figure 1. South-eastern Brazil, indicating the coast of Espírito Santo, Rio de Janeiro, São Paulo and Paraná States.

are relatively well known due to its intensive involvement with coastal fisheries (Di Beneditto et al., 1998; Siciliano, 1994). Consequently, analyses on age and growth parameters of these species were conducted for specimens from south-eastern and southern Brazil (Ramos et al., 2000a; 2000b; Rosas, 2000; Santos, 1999; Schmiegelow, 1990; Zanellato et al., 1996).

Other delphinid species have been frequently reported along the Brazilian coast, e.g. bottlenose dolphin *T. truncatus*, Atlantic spotted dolphin *Stenella frontalis*, rough-toothed dolphin *Steno bredanensis*, 'Brazilian' common dolphin *Delphinus* sp. and the false killer whale *Pseudorca crassidens* (Alves Jr et al., 1996; Barreto, 1995; 2000; Lodi & Capistrano, 1990; Pinedo & Rosas, 1989; Pinedo et al., 1992; Santos, 1999; Schmiegelow, 1990; Simões-Lopes & Ximenez, 1993; Ximenez et al., 1987). However, information on age and growth of these species is poorly known.

This study provides the first compilation on age and growth of some delphinids in south-eastern Brazil (18°25'S–25°45'S). The information currently presented will contribute to further life history research of delphinids in Brazilian waters.

MATERIALS AND METHODS

Data on delphinids were obtained from incidental captures in fishery activities, strandings and museum collections in south-eastern Brazil (18°25'S–25°45'S). The study area includes: Espírito Santo State, from Itaúnas (18°25'S) to Itapemirim (21°00'S); Rio de Janeiro State, from Barra de Itabapoana (21°18'S) to Parati (23°07'S); and São Paulo State, from Ubatuba (23°30'S) to Baía de Paranaguá in the northern Paraná State (25°45'S) (Figure 1).

The specimens have been deposited in the following collections: Museu Nacional/Universidade Federal do Rio de Janeiro (MN), Museu de Zoologia/Universidade de São Paulo (MZUSP), Instituto de Oceanografia/Universidade de São Paulo (IO/USP), Projeto Atlantis/Universidade de São Paulo (PA/USP), Centro de Estudos sobre Encalhes de Mamíferos Marinhos (CEEMAM), Universidade do Estado do Rio de Janeiro/MAQUA (UERJ/MQ) and Organização Consciência Ambiental (ORCA).

A total of 154 delphinids were reported from 1962 to 1999: 44 Atlantic spotted dolphin *S. frontalis*; 36 bottlenose dolphin *T. truncatus*; 26 'Brazilian' common dolphin *Delphinus* sp.; 20 rough-toothed dolphin *S. bredanensis*; 16 Fraser's dolphin *Lagenodelphis hosei*; 3 false killer whale *P. crassidens*; 3 unidentified *Stenella* sp.; 2 pantropical spotted dolphin *S. attenuata*; short-finned pilot whale 2 *Globicephala macrorhynchus*; 1 spinner dolphin *Stenella longirostris;* and 1 striped dolphin *Stenella coeruleoalba*.

Age was estimated by counting the number of GLGs present in the dentine in 74.5% of the sample. We followed the terminology and layers pattern described previously for delphinids (see Perrin & Myrick, 1980; Hohn et al., 1989) and our own experience of the dentinal layers pattern of other species, e.g. *S. guianensis* (Delphinidae) and *Pontoporia blainvillei* (Pontoporiidae) (see Ramos et al., 2000a; 2000b). Only the number of complete dentinal layers was considered for age determination. The results were expressed in years old. Fractions of a layer were only used for calves with less than one complete layer. In those cases, age was considered to be zero or newborn for teeth with only a neonatal line and 0.5 GLG for teeth with a postnatal dentinal layer, but not one complete cycle.

The method of decalcified thin and stained sections of the teeth for the optical microscope was used following the recommendations of Hohn et al. (1989) and Perrin & Myrick (1980). Large straight teeth were selected, stored in glycerine and ethanol (1:1), fixed in 10% formalin and decalcified in RDO (a commercial bone decalcifier) or formic acid 5%. The teeth were cut on the longitudinal plane on a freezing microtome. Labial-lingual sections were cut to a thickness of 40 μm in the teeth. The sections were stained with Mayer's haematoxylin for 40 min and mounted in 100% glycerine. Mid-longitudinal sections with well-marked layers were selected and a standard of reading was established. The counts of the growth layers were made using a compound microscope at magnifications of 25× and 50× and a dissecting microscope at 16× and 50×, both with transmitted light. Three series of readings were accomplished. A fourth reading was accomplished using a microphotograph print of the section where all the growth layers were marked. The sets of counts were then compared. When differences occurred between counts, a best age estimate for each specimen was determined re-examining the section and photography together. To avoid bias in the results, age was estimated without reference to biological data.

The etched half tooth method was used when the decalcification process for thin section was inadequate, mainly for larger teeth. The method of etched half tooth was used following the recommendations of Pierce & Kajimura (1980). The teeth were cut in a longitudinal half-section using a carborundum disc. The surfaces of the longitudinal halves were polished with different grades of whetstone and etched using 5% formic acid for 2 h. After rinsing in

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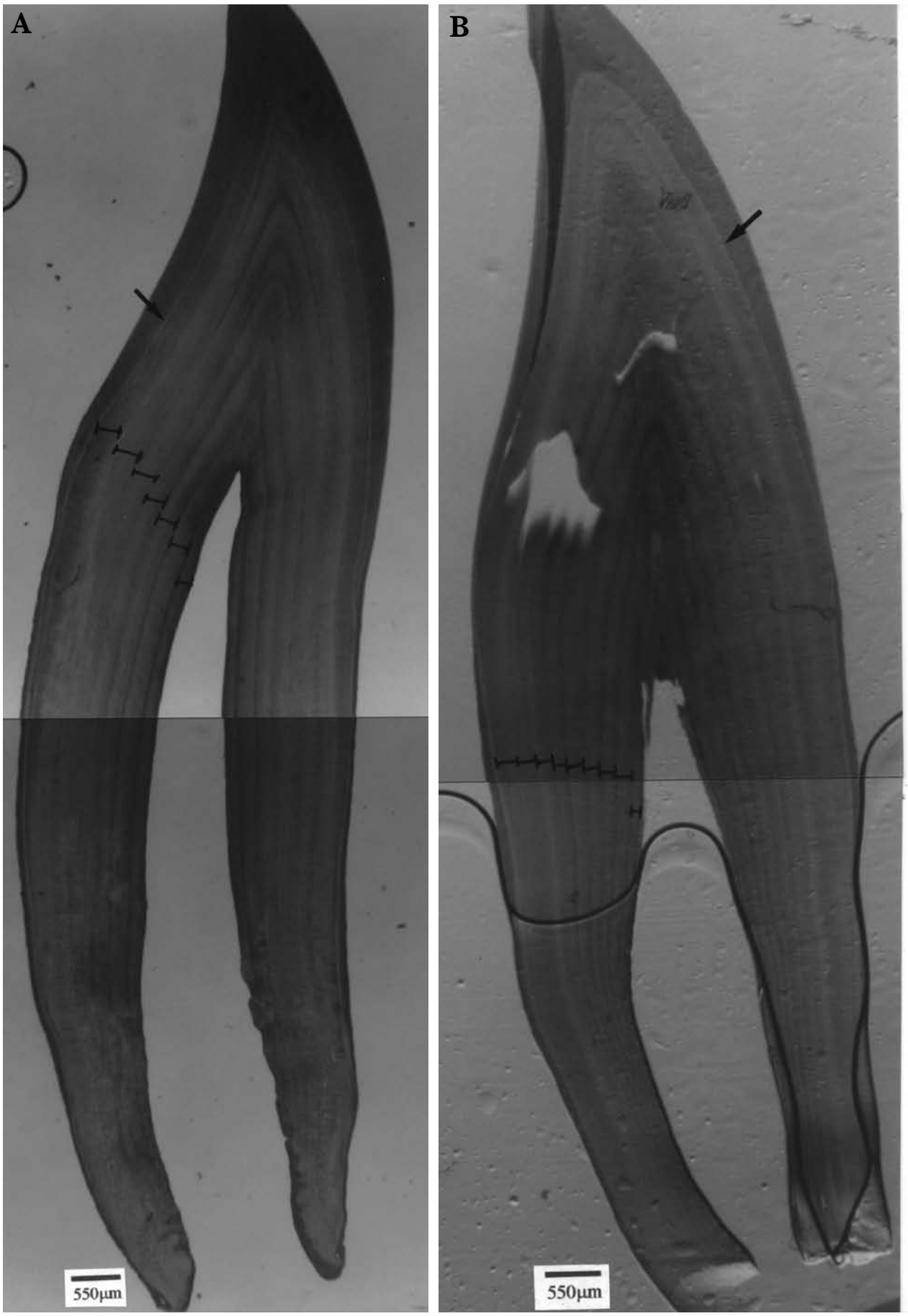

Figure 2. Mid-longitudinal stained thin sections (40 μm) from the tooth of (A) *Stenella frontalis* (PA 047) with seven dentinal layers and (B) a 190.0 cm male *Delphinus* sp. with nine dentinal layers (UERJ/MQ 42) from south-eastern Brazil. The symbols arrow (→) and black line (__) indicate, respectively, the presence of neonatal line and dentinal layer.

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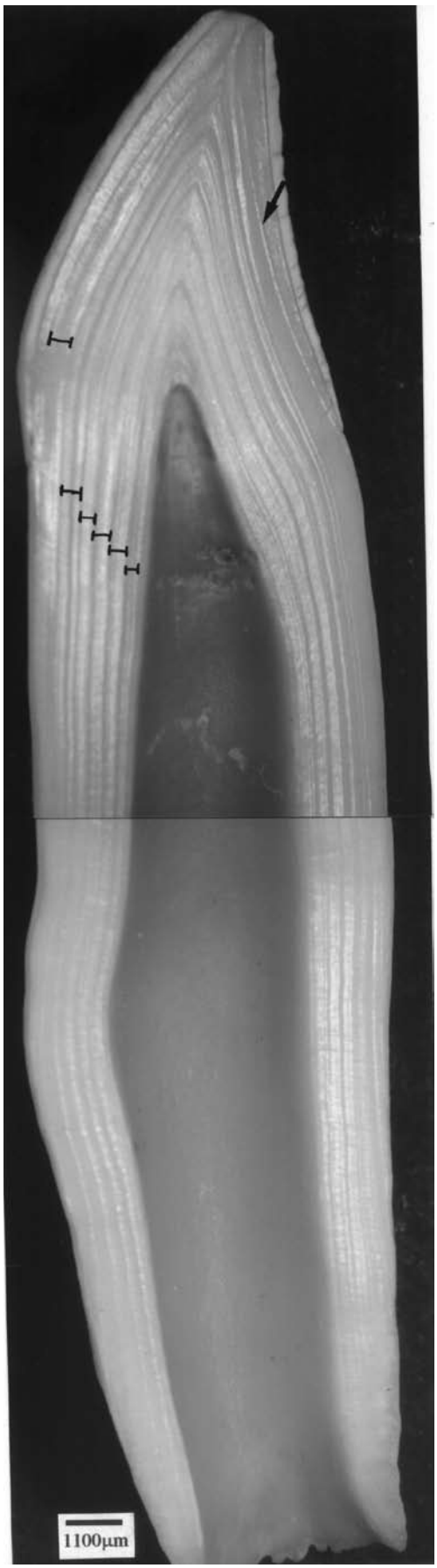

Figure 3. Acid-etched half tooth of a 250.0 cm female *Steno bredanensis* (MN 53648) with six dentinal layers from south-eastern Brazil. The symbols arrow (→) and black line (__) indicate, respectively, the presence of neonatal line and dentinal layer.

Table 1. *Specimens of* Stenella frontalis *(N=44) collected from Espírito Santo (ES), Rio de Janeiro (RJ) and São Paulo (SP) states, south-eastern Brazil.*

No.[Collection]	State/ Latitude	Year	Sex	Age (GLGs)	BL (cm)	Obs.
	ES					
01[1]	21°00'S	1997	F	9	189.0	sp
	RJ					
02	21°18'S	1996	F	–	146.0	nc
03[1]		1999	F	2	145.0	
04[1]	21°35'S	1997	M	5	163.0	
05[1]			M	4	156.5	
06[1]			F	3	159.0	
07[1]		1999	M	5	170.0	
08[2]	22°05'S	1988	M	1	138.1	
09[1]	22°07'S	1992	F	3	170.0	
10[3]	23°00'S	1993	M	12	~201.0	
11[3]		1996	–	7	~165.0	
12[3]			F	11	188.0	
13[3]		1997	–	10	~197.0	
14[3]		1998	M	0	123.0	
15[3]			M	12	197.0	
16[3]			M	–	195.0	
17[3]			M	12	203.0	
18[3]			M	10	216.0	
19[3]			M	9	195.0	
20[3]		1999	F	–	~178.0	
21[1]			F	–	198.0	sp., fve
22[2]	23°05'S	1988	M	12	208.0	
23[1]		1994	–	–	–	
24[3]		1996	M	5	~173.0	
25[3]		1999	M	9	~175.0	
26[1]	23°10'S	1994	–	–	199.0	fve
27[3]			F	11	214.0	
28[3]		1995	–	2	151.0	
29[3]		1996	–	10	~197.0	
30[3]			M	3	171.5	
31[3]		1998	–	–	~160.0	
	SP					
32[4]	24°00'S	1997	M	11	223.0	
33[4]		1998	M	–	155.0	
34[4]			M	–	170.0	
35[4]		1999	F	–	200.0	
36[2]	24°50'S	1987	M	23	218.0	
37[2]			–	–	–	
38[5]		1996	–	16	–	
39[5]			–	1	–	
40[5]			–	7	–	
41[5]			–	6	–	
42[5]			–	12	–	
43[5]		1998	M	6	187.0	
44[2]	25°30'S	1986	–	15	–	

GLGs, growth layer groups; BL, body length, F, female; M, male; [1]Museu Nacional/Universidade Federal do Rio de Janeiro; [2]Museu de Zoologia da Universidade de São Paulo; [3]Universidade do Estado do Rio de Janeiro/MAQUA; [4]Centro de Estudos sobre Encalhes de Mamíferos Marinhos; [5]Projeto Atlantis da Universidade de São Paulo; nc, not collected; sp, spotting pattern; fve, fused vertebral epiphyses; Obs., observations.

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Table 2. *Growth parameter values from the Gompertz growth model fitted to length-at-age data of* Stenella frontalis, Tursiops truncatus, Delphinus *sp.*, Steno bredanensis *and* Lagenodelphis hosei *in south-eastern Brazil.*

Species	N	Age range (GLGs)	Body length range (cm)	Asymptotic length (cm)	Correction factor	Growth rate constant	Correlation coefficient (r)
S. frontalis	27	0–23	123.0–223.0	224.4	–0.5876	0.1473	0.92
T. truncatus	22	0.5–26	166.0–319.0	301.3	–0.6243	0.1601	0.90
Delphinus sp.	17	1–18	154.0–237.0	215.9	–0.4116	0.6151	0.82
S. bredanensis	13	0.5–23	171.5–283.0	258.1	–0.6424	0.5443	0.90
L. hosei	13	1–19	144.0–247.0	231.2	–0.2459	0.9463	0.94

GLGs, growth layer groups.

running water for 24 h, the sections were air dried at room temperature. The pattern of ridges and grooves observed in the surface of the half tooth were accentuated by rubbing the etched surface with soft pencil lead. The GLGs were counted using a binocular dissecting microscope with a magnification of 8×.

Body length was measured by a straight line in axial projections, from the tip of the upper jaw to the notch of the flukes, at 0.5 cm precision. The growth parameters of 92 individuals of *S. frontalis*, *T. truncatus*, *Delphinus* sp., *S. bredanensis* and *L. hosei* were determined by fitting non linear, Gompertz model to length-at-age data, through the Curve Expert v. 1.3 for Windows program: $Y=ae[-e(b-cx)]$, where Y is a measure of size, a is the asymptotic value, b is the correction factor, c is the growth rate constant and x is the age (Zullinger et al., 1984).

When available, additional data about presence of pregnancy, lactation, scars of ovulation in the ovary, sperm in the epididymis, foetus length, and fusion of vertebral epiphyses were obtained (Perrin & Reilly, 1984). The spotting pattern in *S. frontalis* and *S. attenuata* also was observed.

RESULTS AND DISCUSSION

Growth layer groups (GLGs)

One GLG in the stained tooth consisted of a pair of adjacent layers, one narrow unstained layer and one broad stained layer (Figure 2). A fine darkly stained layer demarcated the unstained layer of subsequent GLGs. The unstained layer of the first GLG is the neonatal line, a thin layer strongly marked that begins at birth. The GLG in the etched tooth consisted of one prominent ridge and one groove (Figure 3).

The pattern of GLGs was similar among the several species of delphinids analysed in the present study. However, the GLGs of *Delphinus* and *Stenella* teeth were more conspicuous (Figure 2). The *L. hosei* teeth were often curved and, even so the dentinal layers pattern was very similar, it showed GLGs less conspicuous than observed in the *Delphinus* and *Stenella* teeth. The etched half-tooth for *T. truncatus* and *S. bredanensis* presented an easier procedure than the thin section due to the decalcified time, although the two methods were applied. The dentinal GLG followed the same pattern already described in the literature for *T. truncatus* (see Hohn et al., 1989). The first two layers were slightly more distinct in the etched half-tooth than in the stained thin section because of accessory layers (Figure 3). In stained section the accessory layers might cause difficulty in defining the first layer and often obscure the pattern of layering (see Hohn et al., 1989; Perrin & Myrick, 1980).

The larger teeth belonged to the juvenile individuals of *Globicephala macrorhynchus* and *P. crassidens* and we did not have problems in applying the thin section method. Only one *P. crassidens* was older and we were able to use etched half-tooth. The dentinal layers in this species follow the long axis of the tooth and the last layers approaching an oblique orientation were less conspicuous.

Atlantic spotted dolphin Stenella frontalis

Age was estimated for 33 *S. frontalis* (Table 1). The oldest specimen was 23 y. No specimens at ages of 17–22 y were observed. The distribution of age frequencies show mode at age 12 y (15.1%) and the contribution of older individuals was reduced (9.1%). Individuals aged from zero to 12 y were more represented (90.9%) in the age frequency distribution.

Growth curves fitted to length-at-age data for individuals are presented in Figure 4. Growth parameters estimated through these curves are presented in Table 2. Predicted asymptotic length of 224.4 cm occurs at about 20 y. The length-at-age zero estimated from the Gompertz curve was 128.7 cm. A newborn specimen had the size slightly smaller (123.0 cm) than the predicted length at birth.

Herzing (1990) considered the following age classes for *S. frontalis*: old adults—15+ y; young adults—9 to 15 y; juveniles—4 to 8 y; infants—2 weeks to 3 y; and neonates—1 d to 2 weeks old.

In the present study, only one specimen was more than 20 y (No. 36, Table 1) and two were 15 and 16 y (No. 44 and No. 38). The specimens less than 15 y, measuring up to 223 cm long, could be considered immature individuals (78%). However, specimen No. 26 of 199 cm had already vertebral epiphyses totally fused, indicating physical maturity.

A wide age range for the spotting phase has been observed for *S. frontalis*. Herzing (1990) suggests that the spotting phase occurs at 9–15 y. Specimen No. 1 (189 cm and 9 y) had already shown the spotting pattern.

Bottlenose dolphin Tursiops truncatus

The age range to 29 *T. truncatus* was zero to 26 y old (Table 3). No specimens at ages of 20–25 y were presented in the

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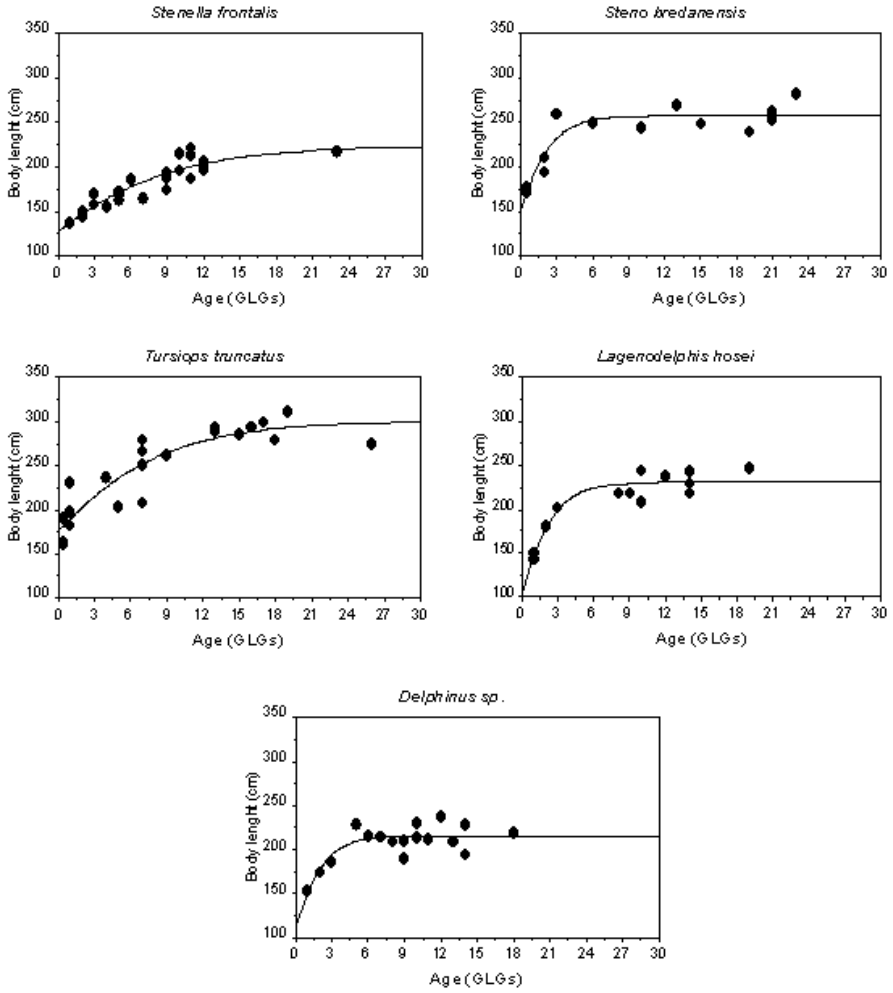

Figure 4. Scatterplots of length-at-age for delphinids (26 *Stenella frontalis*, 22 *Tursiops truncatus*, 16 *Delphinus* sp., 14 *Steno bredanensis* and 13 *Lagenodelphis hosei*) in south-eastern Brazil. The solid line represents the predicted growth trajectory from the Gompertz model (BL: body length; GLGs: growth layer groups).

sample. The distribution of age frequencies was bimodal, with one mode consisting of specimens from 0–1 y (24.1%) and the other from 7–9 y (24.1%). The contribution of individuals to other age-classes was reduced.

The asymptotic length of 301.3 cm predicted by growth curves occurs at about 20 y (Figure 4 and Table 2). The specimen No. 57 of 300 cm had already vertebral epiphyses totally fused, indicating physical maturity. The length-at-age zero estimated from the Gompertz curve was 176.4 cm. The two younger specimens both of 0.5 y were smaller (162.0 and 166.0 cm) than length at birth predicted. Only one foetus was collected (No. 51, Table 3). The female data for this foetus are unknown.

Barreto (1995) estimated the age in 66 *T. truncatus* found stranded along the southern Brazilian coast (~31°–34°S). The oldest animal also was 26 y and individuals up to 2 y represented 49% of the sample. Physical maturity of the skull to functional units was estimated to occur at 5 y.

The age of attainment of the asymptotic body length in our sample at about 20 y was higher in relation to the physical maturity of the skull estimated by Barreto (1995). This difference might be due to the fact that Barreto (1995) used the physical maturity of the skull in contrast to our use of maturity of the body size. Perrin (1975) suggests that the physical maturity of the skull is highly correlated with sexual, and not physical, maturity.

In other areas, the largest animals did not exceed the size of 280.0 cm for males and 260.0 cm for females, approximately. For *T. truncatus* from Texas coastal waters, USA, the Gompertz model gave predicted asymptotic length of 268.0 cm for males and 246.7 cm for females, excluding all specimens less than one year of age. Length-at-age zero predicted from the Gompertz curve was 128.2 cm for males and 115.1 cm for females (Fernandez & Hohn, 1997). The longest male from south-eastern Africa was 257.0 cm and the oldest was 42 y, and the longest female was 249.0 cm and the oldest was 43 y. Both sexes reach their asymptotic size—243.0 cm for males and 238.0 cm for females—between 12 and 15 y (Cockcroft & Ross, 1989).

Read et al. (1993) reported that the Gompertz model provided a good description of the growth of *T. truncatus* from Sarasota, Florida, USA; males (266.4 cm) had greater asymptotic values than females (249.2 cm). Seargeant et al. (1973) presented age–length scatterplots showing that males from north-eastern Florida achieved asymptotic body length of approximately 270.0 cm, compared to about

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Table 3. *Specimens of* Tursiops truncatus *(N=36) found at Espírito Santo (ES), Rio de Janeiro (RJ) and São Paulo (SP) States, south-eastern Brazil, including northern Paraná State (PR).*

No.[Collection]	State/ Latitude	Year	Sex	Age (GLGs)	BL (cm)	Obs.
	ES					
45[6]	20°20'S	1998	M	18	280.0	
	RJ					
46[1]	21°35'S	1992	M	4	237.0	
47[1]			M	1	184.0	
48[1]			M	–	54.0	f
49[1]	22°00'S	1996	F	0.5	166.0	
50[1]	22°05'S	1991	F	0.5	162.0	
51[1]	22°25'S	1992	M	1	200.0	
52[3]	23°00'S	1995	M	15	287.0	
53[3]		1997	–	–	~259.0	
54[2]		?	F	12	–	
55[2]	23°05'S	1985	–	–	280.0	
56[3]		1998	–	–	–	
57[1]	23°07'S	1994	–	–	300.0	fve
58[3]		1995	–	7	266.5	
59[1]		1996	–	16	295.0	
	SP					
60[4]	24°00'S	1997	F	–	315.0	
61[4]			F	9	264.0	
62[4]			–	7	210.0	
63[4]		1998	–	13	290.0	
64[5]	24°50'S	1996	–	19	312.0	
65[5]			–	5	–	
66[5]			F	7	252.0	
67[5]			–	6	–	
68[5]		1997	M	0.5	–	
69[5]			F	17	300.0	
70[5]			–	4	–	
71[5]		1998	–	9	–	
72[2]	25°00'S	1986	–	–	–	
73[2]	25°30'S	1987	–	2	–	
74[5]		1996	–	0.5	193.0	
	PR					
75[5]	25°45'S	1996	–	26	276.0	
76[5]			F	1	232.0	
77[5]		1997	M	5	205.0	
78[5]			M	9	262.0	
79[5]			M	7	280.0	
80[5]			–	13	294.0	

GLGs, growth layer groups; BL, body length; F, female; M, male, [1]Museu Nacional/Universidade Federal do Rio de Janeiro; [2]Museu de Zoologia da Universidade de São Paulo; [3]Universidade do Estado do Rio de Janeiro/MAQUA; [4]Centro de Estudos sobre Encalhes de Mamíferos Marinhos; [5]Projeto Atlantis da Universidade de São Paulo; [6]Organização Consciência Ambiental; f, foetus; fve, fused vertebral epiphyses; Obs., observations.

Table 4. *Specimens of* Delphinus *sp. (N=26) found at Rio de Janeiro (RJ) and São Paulo (SP) States, south-eastern Brazil, including northern Paraná State (PR).*

No.[Collection]	State/ Latitude	Year	Sex	Age (GLGs)	BL (cm)
	RJ				
81[1]	22°05'S	1996	F	1	154.0
82[2]	22°20'S	1987	M	3	187.0
83[3]	23°00'S	1994	M	9	~190.0
84[3]		1998	M	7	215.0
85[2]	23°05'S	1985	–	2	175.0
86[3]		1993	F	–	218.0
87[2]	23°07'S	1962	–	–	–
88[1]		1995	–	–	–
	SP				
89[4]	24°00'S	1999	–	18	220.0
90[2]	24°50'S	1987	–	–	–
91[2]			–	9	211.0
92[2]			–	–	–
93[5]		1997	–	6	216.0
94[5]			–	10	214.0
95[5]		1998	–	11	213.0
96[5]			–	5	228.0
97[2]	25°00'S	1964	–	2	–
98[2]	25°30'S	1986	M	8	210.0
99[2]		1987	–	0.5	–
100[2]			–	–	219.0
101[5]		1996	–	10	230.0
102[5]			M	13	210.0
103[7]	?	?	–	12	237.0
	PR				
104[2]	25°45'S	1987	–	14	195.0
105[2]			–	12	–
106[2]			–	14	228.0

GLGs, growth layergroups; BL, body length; F, female; M, male; [1]Museu Nacional/Universidade Federal do Rio de Janeiro; [2]Museu de Zoologia da Universidade de São Paulo; [3]Universidade do Estado do Rio de Janeiro/MAQUA; [4]Centro de Estudos sobre Encalhes de Mamíferos Marinhos; [5]Projeto Atlantis da Universidade de São Paulo; [7]Instituto de Oceanografia da Universidade de São Paulo.

250.0 cm for females; very similar to the values presented by Read et al. (1993).

Four possible factors could be accepted to explain the considerable difference between the values of asymptotic length and of length-at-age zero obtained for *T. truncatus* in the present study and literature data: (i) the curve in this study was plotted for both sexes—literature data have indicated sexual dimorphism (see Fernandez & Hohn, 1997; Read et al., 1993; Seargeant et al., 1973); (ii) occurrence of large animals in our sample (300.0–315.0 cm)—e.g. the largest male and female in the literature were 280.0 and 260.0 cm, respectively (see Read et al., 1993; Seargeant et al., 1973); (iii) stranding of individuals from two different populations of *T. truncatus*, coastal and offshore—e.g. the offshore animals seem to be larger than those found along the coast (see Hohn, 1980); and (iv) possibly geographical variation—there is incredible variation between different populations of *T. truncatus* (Jefferson et al., 1993).

'Brazilian' common dolphin Delphinus *sp.*

Age estimated for 20 *Delphinus* sp. ranged from 0.5 to 18y (Table 4). The age-classes of 9–14 were better represented

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Table 5. *Specimens of* Steno bredanensis *(N=20) found at Espírito Santo (ES), Rio de Janeiro (RJ) and São Paulo (SP) States, south-eastern Brazil.*

No.[Collection]	State/ Latitude	Year	Sex	Age (GLGs)	BL (cm)	Obs.
	ES					
107[6]	20°20'S	1997	–	2	212.0	
108[6]		1999	–	1	–	
109[6]	20°40'S	1999	F	13	270.0	
	RJ					
110[2]	21°35'S	1987	–	3	–	
111[2]		1988	F	0.5	179.0	
112[1]		1993	M	19	240.0	fve
113[1]	22°05'S	1992	M	0.5	171.5	
114[1]			F	6	250.0	p (#115)
115[1]			M	–	38.0	f
116[2]	22°25'S	1987	M	2	195.0	
117[3]	23°00'S	1995	M	23	283.0	
118[3]		1999	–	–	~194.0	
119[2]	23°05'S	1986	M	24	246.0	
120[1]		1997	F	3	260.0	
121[1]	23°07'S	1994	M	21	263.0	
122[1]			M	10	~244.0	
123[3]		1997	–	23	–	
	SP					
124[4]	24°00'S	1997	M	15	249.0	
125[2]	24°50'S	1987	–	21	254.0	
126[5]	25°00'S	?	–	11	–	

GLGs, growth layer groups; BL, body length; F, female; M, male; [1]Museu Nacional/Universidade Federal do Rio de Janeiro; [2]Museu de Zoologia da Universidade de São Paulo; [3]Universidade do Estado do Rio de Janeiro/MAQUA; [4]Centro de Estudos sobre Encalhes de Mamíferos Marinhos; [5]Projeto Atlantis da Universidade de São Paulo; [6]Organização Consciência Ambiental; p, pregnant; f, foetus; fve, fused vertebral epiphyses; Obs., observations.

Table 6. *Specimens of* Lagenodelphis hosei *(N=16) found at Rio de Janeiro (RJ) and São Paulo (SP) States, south-eastern Brazil.*

No.[Collection]	State/ Latitude	Year	Sex	Age (GLGs)	BL (cm)
	RJ				
127[3]	23°00'S	1997	F	10	245.0
128[1]		1998	–	–	~180.0
129[1]		1999	M	–	220.0
130[3]	23°05'S	1997	M	14	244.0
131[3]			F	14	~220.0
132[3]			M	19	247.0
133[3]			F	1	151.0
134[3]			F	14	230.0
135[3]			M	1	144.0
136[3]			M	2	182.0
137[3]			F	9	~220.0
138[3]			F	3	203.0
139[3]			F	12	238.0
140[3]			M	4	–
141[3]			F	10	210.0
	SP				
142[4]	24°00'S	1999	–	8	220.0

GLGs, growth layer groups; BL, body length; F, female; M, male; [1]Museu Nacional/Universidade Federal do Rio de Janeiro; [3]Universidade do Estado do Rio de Janeiro/MAQUA; [4]Centro de Estudos sobre Encalhes de Mamíferos Marinhos.

(50.0%) in our sample. Only one specimen was 18 y (5.0%). The ages of 0–8 y were under represented; 5.0% by age-class.

Predicted asymptotic length of 215.9 cm occurs at about 5–6 y (Figure 4 and Table 2). The length-at-age zero was estimated from the Gompertz curve at 111.7 cm. The smallest *Delphinus* sp. aged was 154.0 cm and one year old. The single individual of 0.5 y was of unknown length.

Following the criterion of fusion of the premaxillae and the maxillae at the tip of the rostrum, Heyning & Perrin (1994) suggest that mature male *D. capensis* ranged from 202.0 to 235.0 cm and females 193.0 to 224.0 cm long. Considering age and length predicted by our curve, 22.6% of the specimens may be considered immature individuals, 48.4% mature while for 29.0% it was not possible to measure and collect teeth for age estimation.

Rough-toothed dolphin Steno bredanensis

The age range for 18 *S. bredanensis* was zero to 24 y (Table 5). Age-classes 0–3 y and 19–24 y were the most representative; 38.8% and 33.3%, respectively. A gap was observed among the age-classes from 4 to 18 y. The contribution of individuals in these age-classes was reduced; 5.6% by age.

The age of specimen No. 119 had been previously estimated as 33 y (Siciliano et al., 1987). We were able to count only 24 GLGs. The difference in the number of GLGs could be due to: (i) distinct GLG pattern during one complete year; (ii) counting of accessory layers; or (iii) decrease in the acuity of count of the last layers in the etched half tooth used by us. Then, we exclude this individual of growth curve fitted to length-at-age data.

The asymptotic length of 258.1 cm predicted by growth curves occurs at about 10 y (Figure 4 and Table 2). The length-at-age zero estimated from the Gompertz curve was 152.5 cm. The two younger specimens measured, both 0.5 y, was higher (172.0 and 179.0 cm) than the predicted length at birth. Only one foetus was collected (No. 115, Table 5)—5% of the sample. The pregnant female (No. 114) was 6 y and 250.0 cm long.

The asymptotic length predicted by growth curves in our specimens (10 y) is within the size range for adults of *S. bredanensis* (e.g. Miyazaki, 1980). Miyazaki (1980) suggests that males of *S. bredanensis* reach a larger maximum size than females; 253.0 cm for males and 247.0 cm for females and sexual maturity is reached by the male at 231.0 cm long or 14 dentinal layers, and by the female at 225.0 cm, or 17 layers. However, the pregnant specimen (No. 114) of the present study had already reached sexual maturity at 6 y. All the animals analysed by Miyazaki (1980) were adults of more than 15 y. Perhaps, the age at attainment of sexual maturity estimated by Miyasaki (1980) might be overestimated due to absence of younger animals (<15 y).

Regarding the other individuals in our sample, 60.0% had body length between 240.0 and 283.0 cm and were

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10 y or older. A male of 19 y and 240.0 cm (No. 112) had already vertebral epiphyses totally fused, indicating physical maturity. The juveniles (35.0%) had body lengths from 171.5 to 212.0 cm and up to 3 y.

Fraser's dolphin Lagenodelphis hosei

Age estimated for 14 *L. hosei* ranged from one to 19 y (Table 6). The distribution of age frequencies shows mode at age 14 y (21.4%); however, two age-classes were dominant from 1–4 y (35.7%) and 8–14 y (57.1%). No specimens at ages 15–18 y were present in the sample.

The asymptotic length of 231.2 cm predicted by growth curves occurs at about 7–8 y (Figure 4 and Table 2). The length-at-age zero estimated from the Gompertz curve was 105.8 cm. No newborn was present in the sample.

Life history parameters of *L. hosei* were examined by Amano et al. (1996) from a school captured in Japan. Age and body length at sexual maturity was estimated at 7–10 y and 220–230.0 cm long in males and 5–8 y and 210–220.0 cm long in females. Both sexes reach the asymptotic length at about age of 10 y: 230–260.0 cm in males and 220–250.0 cm in females. Mignucci-Giannoni et al. (1999) estimated the age in two *L. hosei* specimens found off Puerto Rico. The age of 3 y was estimated for a 227.0 cm subadult male and the age of a second, a 121.0 cm female, was estimated at less than a week old. The authors considered this consistent with Amano et al. (1996) who suggested length-at-birth at around 100.0 cm and 124.0 cm long.

Van Bree et al. (1986) analysed 11 individuals of *L. hosei* collected in a mass stranding off the northern coast of Brittany, France. The authors suggest that males and females reach sexual maturity from a total body length of 230.0 cm and at about 7 y minimum age.

The asymptotic length predicted by our growth curve (231.2 cm long at about 7–8 y) is within the estimate of maturity for *L. hosei*. Therefore, of the 13 specimens mass-stranded at Rio de Janeiro State from November to December 1997, 61.5% were adults and 38.5% juveniles. The relationship between age and body length indicates that the specimens collected in the following years may also be considered as adults (Nos. 128, 129 and 142, Table 6).

Amano et al. (1996) suggested that *L. hosei* could have a relatively shorter longevity than other pelagic delphinids; the oldest specimens in Japan were two males and a female of 17.5 y. Van Bree et al. (1986) showed that the oldest dolphin was 16 y. The oldest individual in our sample was 19 y, which supports the above considerations.

False killer whale Pseudorca crassidens

Two out of three *P. crassidens* examined in our sample were zero year: a 179.0 cm female (MN) incidentally captured in gillnet fishery off northern Rio de Janeiro State (~21°S) in 1992 and a 177.0 cm male (UERJ/MQ) stranded in the eastern Rio de Janeiro State (23°00'S) in 1995. The teeth sections in both specimens showed only the neonatal line and they were considered newborns. The third individual, 503.0 cm long of unknown sex (UERJ/MQ) was found stranded in eastern Rio de Janeiro State (23°00S). The age was estimated as 14 y.

Adults of *P. crassidens* are up to 600.0 cm (males) or 500.0 cm (females) long. Newborns are 150.0 to 210.0 cm (Jefferson et al., 1993). Pinedo & Rosas (1989) estimated the age of four *P. crassidens* found off the Rio Grande do Sul State coast, southern Brazil (~32°S). A 436.0 cm male was 10 y, two females measuring 412.0 and 440.0 cm long were 17 and 18 y, respectively, and a 391.0 cm long specimen of unknown sex was 12 y. The authors considered all to be adults.

The oldest specimen in our sample had the age corresponding to a mature individual. No seasonality in breeding is known for *P. crassidens* (Jefferson et al., 1993). Our two newborns were collected in different seasons (July—austral winter and November—austral spring).

Unidentified Stenella *sp.*

Species identification was not possible in three *Stenella* specimens (CEEMAM) found stranded in São Paulo State (24°00'S). A 210.0 cm male with no teeth for age estimation, a 205.0 cm male at 11 y and a 202.0 cm female at 8 y.

Pantropical spotted dolphin Stenella attenuata

Two individuals of *S. attenuata* (UERJ/MQ) were found stranded in eastern Rio de Janeiro State (23°00'S); a 194.0 cm female at 11 y in 1995, and a 195.0 cm male with no teeth for age estimation in 1997. The total length of our two specimens and the age estimated for the female is within the size range known for mature dolphins.

Perrin et al. (1976) estimated the average age at attainment of sexual maturity for offshore eastern tropical Pacific pantropical spotted dolphins. Sexual maturity was approximately 12 layers and average length about 195.0 cm in males. Females attain sexual maturity on the average at about 9 layers and 181.0 cm long. Asymptotic length was 190.0 cm at predicted age of 18 layers for females and 206.0 cm achieved at predicted age of 26 layers for males.

Growth of *S. attenuata* on the Pacific coast of Japan is well known (see Kasuya, 1976, 1985; Kasuya et al., 1974). Sexual maturity is attained at 8.2 y in females and 10.3 y in males (Kasuya et al., 1974). The asymptotic length in females is estimated to be 193.9 cm at ages greater than 12 y. The mean growth curve of the male indicates slower growth after 12 y and seems to reach the asymptotic length of 207.1 cm at about 22 y (Kasuya, 1976).

Short-finned pilot whale Globicephala macrorhynchus

Schmiegelow (1990) reported a *G. macrorhynchus* (MZUSP) collected in São Paulo State (24°50'S) in 1986. The body length and sex are unknown and the teeth were not collected. In 1997, a 235.0 cm specimen (ORCA) was collected in Espírito Santo State (20º40'S). We estimated an age of 2 y for this specimen.

Kasuya & Matsui (1984) estimated that the maximum age attained by *G. macrorhynchus* was 62 y for females and 45 y for males. Females attain sexual maturity at 9 y and reached the asymptotic length of 364.0 cm at age 22 y. The male growth was similar to that of the female until age 9 y, when the secondary male growth spurt started. Males attained an asymptotic length of 473.5 cm at 27 y.

The relationship between age and body length of our specimen, a 235.0 cm juvenile at 2 y, is in good agreement with

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the age–length predicted by growth curve for *G. macrorhynchus* off the Pacific coast of Japan (see Kasuya & Matsui, 1984).

Spinner dolphin Stenella longirostris

In 1999, a 109.5 cm female was found stranded in southern Rio de Janeiro State (23°05'S) (UERJ/MQ) and had less than one complete layer in the teeth. We did not consider this female a newborn since it had already deposited dentinal layers.

In the eastern tropical Pacific, the length at birth estimated was 75.5 cm long (Perrin et al., 1975). Later, Perrin et al. (1977) estimated average length at birth of 76.9 cm and the largest foetus found was 84.0 cm. Average body length of the adult female was 170.6 cm (range from 153.0 to 187.0 cm) and attainment of sexual maturity at 167.0 cm. Males attain sexual maturity at 170.0 cm and the average length of the adult was 175.5 cm (range from 160.0 to 192.0 cm) (Perrin et al., 1975).

Barreto & Lodi (2000) estimated the age of two female *S. longirostris* collected in north-eastern Brazil (3°51'S): a 187.0 cm individual considered an adult of at least 18 y, and a 149.0 cm juvenile between 1 and 2 y old. Considering the small sample size no extensive comparisons were possible.

Striped dolphin Stenella coeruleoalba

In 1999, a *S. coeruleoalba* was found stranded in eastern Rio de Janeiro State (23°00'S) (UERJ/MQ). The age was estimated at 21 y. The body length and sex could not be determined, but according to published data on growth of *S. coeruleoalba* we considered this specimen as an adult.

The life history of *S. coeruleoalba* is well known for the Pacific coast of Japan (see Kasuya, 1972, 1976, 1985; Miyazaki, 1977). Kasuya (1972) estimated that *S. coeruleoalba* attain sexual maturity at 9 y and 212.0 cm long in females and 220.0 cm long in males, and physical maturity at 14 to 15 y and 222.0 cm long in females and 236.0 cm long in males. Miyazaki (1977) estimated the mean age at attainment of sexual maturity of males at 8.7 y (219.0 cm) and of females at 8.8 y (216.0 cm).

CONCLUSIONS

In conclusion, the age-at-length data were consistent for *S. frontalis*, *Delphinus* sp., *S. bredanensis* and *L. hosei*, suggesting a good agreement with previous work on these species. For *T. truncatus*, the age at asymptotic length obtained in this study might be confirmed by increasing the sample size. The results obtained for *P. crassidens*, *Stenella* sp., *S. attenuata*, *S. longirostris*, *S. coeruleoalba* and *G. macrorhynchus* were limited because of the small sample size available. No extensive comparisons were possible for these species.

While the sample analysed in the present study is small and it is not possible to draw many inferences about population structure and geographical variation based solely on these data, some parameters estimated are consistent with previous findings for these species of delphinids. The results of the present study will be helpful to create a new scenario about the biological knowledge of the delphinids on the western south Atlantic coast of Brazil.

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REFERENCES

Amano, M., Miyazaki, N. & Yanagisawa F., 1996. Life history of Fraser's dolphin, *Lagenodelphis hosei*, based on a school captured off the Pacific coast of Japan. *Marine Mammal Science*, **12**, 199–214.

Alves Jr, T.T, Ávila, F.J.C., Oliveira, J.A., Furtado Neto, M.A.A. & Monteiro Neto, C., 1996. Registros de cetáceos para o litoral do Estado do Ceará, Brasil. *Arquivos de Ciências do Mar*, **30**, 79–92.

Barreto, A.S., 1995. *Idade e desenvolvimento craniano de* Tursiops truncatus *(Delphinidae, Cetacea) do litoral sudeste do Brasil*. MSc thesis, Fundação Universidade Federal do Rio Grande, Rio Grande, Brazil.

Barreto, A.S., 2000. *Variação craniana e genética de* Tursiops *(Delphinidae, Cetacea) na costa Atlântica da América do Sul*. PhD thesis, Fundação Universidade Federal do Rio Grande, Rio Grande, Brazil.

Barreto, A. & Lodi, L., 2000. Estimativa de idades do golfinho-rotator, *Stenella longirostris* (Cetacea, Delphinidae) no nordeste do Brasil. *Bioikos*, **14**, 24–27.

Chivers, S.J. & Myrick Jr, C., 1993. Comparison of age at sexual maturity and other reproductive parameters for two stocks of spotted dolphin, *Stenella attenuata*. *Fishery Bulletin*, **91**, 611–618.

Cockcroft, V.G. & Ross, G.J.B., 1989. Age, growth and reproduction of bottlenose dolphins *Tursiops truncatus* from the east coast of southern Africa. *Fishery Bulletin*, **88**, 289–302.

Di Beneditto, A.P.M., Ramos, R.M.A. & Lima, N.R.W., 1998. Fishing activity in northern Rio de Janeiro State (Brazil) and its relation with small cetaceans. *Brazilian Archives of Biology and Technology*, **41**, 296–302.

Fernandez, S. & Hohn, A.A., 1998. Age, growth and calving season of bottlenose dolphins, *Tursiops truncatus*, of coastal Texas. *Fishery Bulletin*, **96**, 357–365.

Herzing, D., 1990, Underwater and close up with spotted dolphins. *Whalewatcher*, **24**, 16–19.

Heyning, J.E. & Perrin, W.F., 1994. Evidence for two species of common dolphins (genus *Delphinus*) from the eastern north Pacific. *Contributions in Science LA County Museum of Natural History*, **442**, 1–35.

Hohn, A.A., 1980. Age determination and age-related factor in the teeth of western north Atlantic bottlenose dolphins. *Scientific Reports of the Whales Research Institute*, **32**, 39–66.

Hohn, A.A., 1990. Reading between the lines: analysis of age determination in dolphins. In *The bottlenose dolphin* (ed. S. Leatherwood and R.R. Reeves), pp. 575–585. San Diego: Academic Press.

Hohn, A.A. & Hammond, P.S., 1985. Early postnatal growth of the spotted dolphin, *Stenella attenuata*, in the offshore eastern tropical Pacific. *Fishery Bulletin*, **83**, 553–566.

Hohn, A.A., Scott M.D., Wells, R.S., Sweeney, J.C. & Irvine, A.B., 1989. Growth layers in teeth from known age, free-ranging bottlenose dolphins. *Marine Mammal Science*, **5**, 315–342.

Jefferson, T.A., Leatherwood, S. & Webber, M.A., 1993. *FAO species identification guide, marine mammals of the world*. Rome: FAO-UNEP. 320 pp.

Kasuya, T., 1972. Growth and reproduction of *Stenella coeruleoalba* based on the age determination by means of dentinal growth layers. *Scientific Reports of the Whales Research Institute*, **24**, 57–79.

Kasuya, T., 1976. Reconsideration of life history parameters of the spotted and striped dolphins based on cemental layers. *Scientific Reports of the Whales Research Institute*, **28**, 73–106.

Kasuya, T., 1985. Effect of exploitation on reproductive parameters of the spotted and striped dolphins off the Pacific coast of Japan. *Scientific Reports of the Whales Research Institute*, **36**, 107–138.

Kasuya, T. & Matsui, S., 1984. Age determination and growth of the short-finned pilot whale off the Pacific coast of Japan. *Scientific Reports of the Whales Research Institute*, **35**, 57–91.

Kasuya, T., Miyazaki, N. & Dawbin, W.H., 1974. Growth and reproduction of *Stenella attenuata* in the Pacific coast of Japan. *Scientific Reports of the Whales Research Institute*, **26**, 157–226.

Lodi, L. & Capistrano, L., 1990. Capturas acidentais de pequenos cetáceos no litoral norte do Estado do Rio de Janeiro. *Biotemas*, **3**, 47–65.

Mignucci-Giannoni, A.A., Montoya-Ospina, R.A., Pérez-Zoyas, J.J., Rodriguez-López, M.A. & Williams Jr, E.H., 1999. New record of Fraser's dolphins (*Lagenodelphis hosei*) for the Caribbean. *Aquatic Mammals*, **25**, 15–19.

Miyazaki, N., 1977. Growth and reproduction of *Stenella coeruleoalba* off the Pacific coast of Japan. *Scientific Reports of the Whales Research Institute*, **29**, 21–48.

Miyazaki, N., 1980. Preliminary note on age determination and growth of the rough-toothed dolphin, *Steno bredanensis*, off the Pacific Coast of Japan. *Reports of the International Whaling Commission*, special issue, **3**, 171–179.

Perrrin, W.F., 1975. Distribution and differentiation of populations of dolphins of the genus *Stenella* in the Eastern Tropical Pacific. *Journal of the Fisheries Research Board of Canada*, **32**, 1059–1067.

Perrin, W.F., Holts, D.B. & Miller, R.B., 1975. Preliminary estimates of some parameters of growth and reproduction of the eastern spinner porpoise, *Stenella longirostris* subspecies south-west. *Southwest Fisheries Center Administrative Report*.

Perrin, W.F., Col, J.M. & Zweifel, J.R., 1976. Growth and reproduction of the spotted porpoise, *Stenella attenuata*, in the offshore eastern tropical Pacific. *Fishery Bulletin*, **74**, 229–270.

Perrin, W.F., Holts, D.B. & Miller, R.B., 1977. Growth and reproduction of the eastern spinner dolphin. A geographical form of *Stenella longirostris* in the eastern tropical Pacific. *Fishery Buletin*, **75**, 725–750.

Perrin, W.F. & Myrick Jr, A.C., ed., 1980. Reports of the International Whaling Commission. In *Age determination of toothed whales and sirenians. Reports of the International Whaling Commission*. special issue, **3**, 1–50.

Perrin, W.F. & Reily, S.B., 1984. Reproductive parameters of dolphins and small whales of the family Delphinidae. *Reports of the International Whaling Commission*, special issue, **6**, 97–133.

Pierce, K.V. & Kajimura, H., 1980. Acid etching and highlighting for defining growth layers in cetacean teeth. *Reports of the International Whaling Commission*, special issue, **3**, 99–104.

Pinedo, M.C. & Hohn, A.A., 2000. Growth layer patterns in teeth from the franciscana, *Pontoporia blainvillei*: developing a model for precision in age estimation. *Marine Mammal Science*, **16**, 1–27.

Pinedo, M.C. & Rosas, F.C.W., 1989. Novas ocorrências de *Pseudorca crassidens* (Cetacea, Delphinidae) para o Atlântico Sul Ocidental, com observações sobre medidas cranianas e alimentação. *Atlântica*, **11**, 77–83.

Pinedo, M.C., Rosas, F.C.W. & Marmontel, M., 1992. *Cetáceos e pinípedes do Brasil: uma revisão dos registros e guia para identificação das espécies*. Manaus: UNEP/FUA. 213 pp.

Ramos, R.M.A., Di Beneditto, A.P.M. & Lima, N.R.W., 2000a. Growth parameters of *Pontoporia blainvillei* and *Sotalia fluviatilis* (Cetacea) in northern Rio de Janeiro, Brazil. *Aquatic Mammals*, **26**, 65–75.

Ramos, R.M.A., Di Beneditto, A.P.M. & Lima, N.R.W., 2000b. Relationship between body length or age and dental morphology in *Pontoporia blainvillei* and *Sotalia fluviatilis* (Cetacea) in northern Rio de Janeiro, Brazil. *Revista Brasileira de Biologia*, **60**, 283–290.

Read, A.J., Wells, R.S., Hohn, A.A. & Scott, M.D., 1993, Patterns of growth in wild bottlenose dolphins, *Tursiops truncatus*. *Journal of Zoology*, **231**, 107–123.

Rosas, F.C.W., 2000. *Interações com a pesca, mortalidade, idade, reprodução e crescimento de* Sotalia guianensis *e* Pontoporia blainvillei *(Cetacea, Delphinidae e Pontoporiidae) no litoral sul do Estado de São Paulo e litoral do Estado do Paraná, Brasil*. PhD thesis, Universidade do Paraná, Curitiba, Brazil.

Santos, M.C.O., 1999. *Novas informações sobre cetáceos no litoral sul de São Paulo e norte do Paraná com base em estudos sobre encalhes e na aplicação da técnica de foto-identificação individual de* Sotalia fluviatilis *(Cetacea, Delphinidae)*. MSc thesis, Universidade de São Paulo, São Paulo, Brazil.

Schmiegelow, J.M.M., 1990. *Estudo sobre cetáceos odontocetos encontrados em praias da região entre Iguape (SP) e Baía de Paranaguá (PR)(24°42'S–25°28'S) com especial referência a* Sotalia fluviatilis *(Gervais, 1853) (Delphinidae)*. MSc thesis, Universidade de São Paulo, São Paulo, Brazil.

Sergeant, D.E., 1959. Age determination in odontocete whales from dentinal growth layers. *Norsk Hvalfangsttid*, **48**, 273–288.

Sergeant, D.E., Caldwell, D.K. & Caldwell, M.C., 1973. Age, growth and maturity of bottlenosed dolphin (*Tursiops truncatus*) from northeast Florida. *Journal of the Fisheries Research Board of Canada*, **30**, 1009–1011.

Siciliano, S., 1994. Review of small cetaceans and fishery interactions in coastal waters of Brazil. *Reports of the International Whaling Commission*, special issue, **15**, 241–250.

Siciliano, S., De Andrade, L. & Capistrano L., 1987. Observações sobre a presença de *Tursiops truncatus* e *Steno bredanensis* na Baía de Guanabara, Rio de Janeiro—Brasil. In *II Reunião de Trabalho de Especialistas em Mamíferos Aquáticos da América do Sul*. Fundação Brasileira para a Conservação da Natureza, Rio de Janeiro, Brazil.

Simões-Lopes, P.C. & Ximenez, A., 1993. Annotated list of the cetaceans of Santa Catarina coastal waters, southern Brazil. *Biotemas*, **6**, 67–92.

Van Bree, P.J.H., Collet, A., Desportes, G., Hussenot, E. & Raga, J.A., 1986. Le dauphin de Fraser, *Lagonodelphis hosei* (Cetacea, Odontoceti), espéce nouvelle pour la faune d'Europe. *Mammalia*, **50**, 57–86.

Ximenez, A., Simões-Lopes, P.C. & Praderi, R., 1987. Notas sobre mamíferos marinhos de Santa Catarina e Rio Grande do Sul (Pinnipedia-Cetacea). In *II Reunião de Trabalho de Especialistas em Mamíferos Aquáticos da América do Sul*. Fundação Brasileira para a Conservação da Natureza, Rio de Janeiro, Brazil.

Zanelatto, R.C., Dans, S. & Crespo, E.A., 1996. Análise da estrutura de idade de uma população de *Sotalia fluviatilis* Gray, 1866 (Cetacea, Delphinidae) capturadas acidentalmente durante a atividade pesqueira no litoral do Estado do Paraná, Brasil. In *VII Reunion de Trabajo de Especialistas en Mamiferos Acuáticos de America de Sur, Vinã del Mar, Chile*, pp. 64.

Zullinger, E.M., Ricklefs, R.E., Redford, K.H. & Mace, G.M., 1984. Fitting sigmoidal equations to mammalian growth curves. *Journal of Mammalogy*, **65**, 607–636.

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