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Organ Weights and Growth Profiles in Bottlenose Dolphins (*Tursiops truncatus*) from the Northwestern Gulf of Mexico

Jason P. Turner,[1] Lance S. Clark,[2] Elsa M. Haubold,[2,3]
Graham A. J. Worthy,[1,2] and Daniel F. Cowan[2,3]

[1]*Physiological Ecology and Bioenergetics Laboratory, Texas A&M University–Galveston, Galveston, TX 77551, USA*
[2]*Texas Marine Mammal Stranding Network, Galveston, TX 77551-5926, USA*
[3]*Department of Pathology, and the Marine Biomedical Institute, University of Texas Medical Branch, Galveston, TX 77555-0555, USA*

Current Addresses: Department of Marine Science, University of Hawai'i at Hilo, Hilo, HI 96720 (JPT)
Department of Biological Sciences, University of Alaska–Anchorage, Anchorage, AK 99508 (LSC)
Florida Fish and Wildlife Conservation Commission, St. Petersburg, FL 33701-5095 (EMH)
Department of Biology, University of Central Florida, Orlando, FL 32816-2368 (GAJW)

Abstract

Systematic necropsies were performed on 63 bottlenose dolphins (*Tursiops truncatus*), and data on organ mass, standard body length (SBL), body mass (BM), gender, sexual maturity, and age were measured and/or estimated. Animals were extremely fresh and recovered from along the Texas and Louisiana coastline in the northwestern Gulf of Mexico. Organ reference tables were established for this species to facilitate comparisons with other bottlenose dolphins and to provide a baseline for other cetacean species. Organs examined included lungs, adrenal glands, kidneys, testes, ovaries, heart, liver, pancreas, brain, pituitary, thyroid, thymus, and spleen. Individuals were separated into three size classes: < 175 cm, 175-225 cm, and > 225 cm, based on SBL to further facilitate comparisons. Growth rates of length and mass were described using Gompertz nonlinear models as a function of gender. No sexual dimorphism was identified in BM or organ weights, and SBL was only significantly larger for older mature males. SBL and BM were strongly correlated with age when all animals were included in analyses, although this is not an accurate predictor of age, especially in older individuals. Organ weights were significantly correlated with both SBL (except thymus and spleen) and BM (except left ovary, spleen, and thymus). Age was significantly correlated with all organ weights (except thymus, thyroid, and ovaries). There were no significant differences in the weight of any paired organs (adrenal glands, kidneys, lungs, ovaries, testes), and all were significantly correlated with BM. These data on organ weights of bottlenose dolphins, when interpreted with SBL, BM, and age, are significant tools for pathologists and veterinarians interpreting animal health status.

Key Words: organ weights, bottlenose dolphin, *Tursiops truncatus*, growth profile, marine mammal, organ weights, stranding, Gulf of Mexico

Introduction

Cetacean (dolphins and whales) strandings along the Texas coast are relatively common with an average stranding rate of 138 animals per year (Worthy, 1998). Stranded animals, whether dead or alive, are of great biological importance to the scientific community. These specimens provide invaluable information pertaining to identification of new species, their natural history and ecology, diseases, and the potentially adverse effects of environmental conditions. By analyzing and interpreting tissues from these stranded animals, scientists will be better able to diagnose and treat illnesses in live dolphins and further understand the potentially problematic effects of oceanic pollution or contamination. To better interpret pathological changes in these animals, it is important to first understand the normal variability in organ size as a function of age and body mass (BM). Therefore, it has become necessary to supplement our knowledge of cetaceans inhabiting coastal oceans via comprehensive assessments of the various organ systems within these animals.

From 1991 to 2003, the weight of nearly every organ, as well as standard body length (SBL), BM, gender, sexual maturity status, and animal age, was determined from beach stranded Atlantic bottlenose dolphins (*Tursiops truncatus*) along the

Texas and Louisiana coasts in northwestern Gulf of Mexico (GOM). Although bottlenose dolphins are cosmopolitan in their distribution (except for the high latitudes) and are one of the dominant cetacean species inhabiting many coastal seas, information regarding specific organ weights and their correlation with measures of SBL, BM, and age are limited at best.

The purpose of the present study was to establish baseline data for organ weights in bottlenose dolphins (*T. truncatus*) and to generate tables of reference for use in identifying abnormally sized organs (e.g., enlarged or stunted) that often correspond with disease or exposure to toxic substances. Furthermore, we sought to determine whether organ weights correlate with SBL, BM, or age in bottlenose dolphins throughout their life history. Finally, we tested for sexual dimorphic characteristics of SBL, BM, and individual organ weights in these animals and compared them to published values for similar delphinids.

These data from the present study will provide organ weight reference measurements for comparison with other bottlenose dolphins or other cetacean species. To our knowledge, organ weights and growth profiles have not been established for this species within the GOM. Fernandez & Hohn (1998) recorded age and growth profiles in the same population from 1981 to 1990, the period immediately preceding our period of observation, but did not include organ weights in their study. Thus, the focus of the present study was to provide organ weights and growth data on bottlenose dolphins from the northwestern GOM for reference and comparison with other specimens examined elsewhere.

Materials and Methods

Number and Source of Animals

Bottlenose dolphins included in this study (n = 63) were collected by the Texas Marine Mammal Stranding Network (TMMSN), under the auspices of the National Marine Fisheries Service. The collection area ranged along the entire Texas Gulf coast and part of western Louisiana (Brownsville, Texas at the Texas/Mexican border to Cameron Parish in Louisiana; Figure 1). Animals examined had either stranded alive and died shortly afterwards (n = 21), stranded already deceased (n = 38), or were accidentally net-captured/killed (n = 4).

Age and Sexual Maturity Determination

Age was estimated in a subsample of bottlenose dolphins (n = 36) where teeth samples were collected; no estimation or approximation of age was determined for animals where teeth were not available. Estimation of age was conducted by counting the growth layer groups (GLGs) of dentinal lamination of the teeth following methods described by Hohn et al. (1989) and Turner (1998). This method of age estimation is widely accepted as an accurate determination of age in dolphins, porpoises, and toothed whales; each growth layer group equals one year (e.g., Hohn, 1980; Perrin & Myrick, 1980). Sexual maturity in males was determined by gross and histological identification of spermatozoa in the testes and epididymis, and in females by the presence or absence of follicular development or *corpora lutea*.

Selection and Sampling

All animals were brought to the TMMSN's state laboratory at Texas A&M University at Galveston for necropsy, which included gross examination and systematic histological sampling of lungs, adrenal glands, kidneys, testes, ovaries, heart, liver, pancreas, brain, pituitary, thyroid, thymus, and spleen. All methods for necropsy, gross examination, and histological sampling were standardized by one of us (DFC) for the duration of the study. Only freshly dead animals (< 24 h), suitable for histological examination, were included in this study. During the course of necropsy, all viscera were removed, as well as all soft tissues from the skeleton. All organs were weighed (g) on a Sartorius model 4800P electronic platform scale from 1991 to 2001, and on a Mettler/Toledo AB54-S thereafter, and later dissected, including gross and microscopic tissue examination. Individual dolphins were initially separated into two groups—above or below 225 cm SBL—based on organ weights that correspond to the onset of sexual maturity and a SBL of 225 cm; however, since dolphins < 225 cm tend to be immature, but undergo very different life histories, specimens were further separated into three groups (Groups A, B, and C) for further analysis based on SBL. Group A consisted of dolphins less than 175 cm (n = 7; 5 females and 2 males), Group B were dolphins between 175 and 225 cm (n = 20; 9 females and 11 males), and dolphins in Group C were greater than 225 cm in length (n = 36; 17 females and 19 males) (Figures 1 & 2).

During the necropsy, all tissue samples collected were placed in 10% neutral buffered formalin for a period of 7 to 14 d for fixation. After fixation, these tissues were processed for routine histological examination to determine whether these organs were normal (without pathologies). Briefly, tissue samples were embedded in paraffin wax, sectioned at 5 to 7 µm, and stained with either Hematoxylin and Eosin (H&E) or Hematoxylin, Phloxine, and Saffron (HPS) (a trichrome stain used to differentiate collagen from muscle). Histological examination was used to support evaluation of organs as

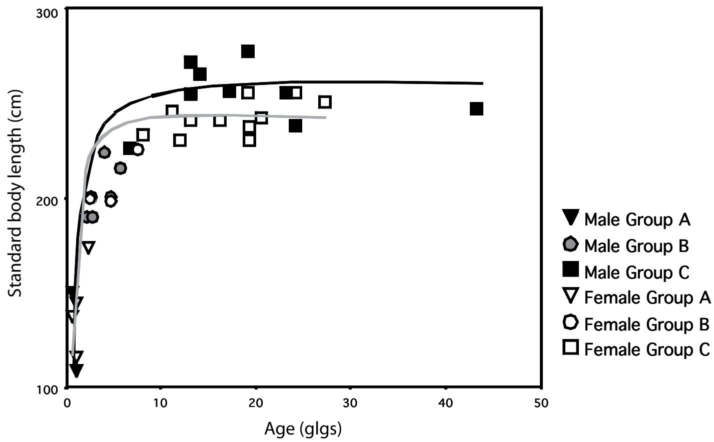


Figure 1. Scatterplot (with Gompertz curve) of age (growth layer groups) versus standard body length (cm) of male and female bottlenose dolphins from the northwestern Gulf of Mexico

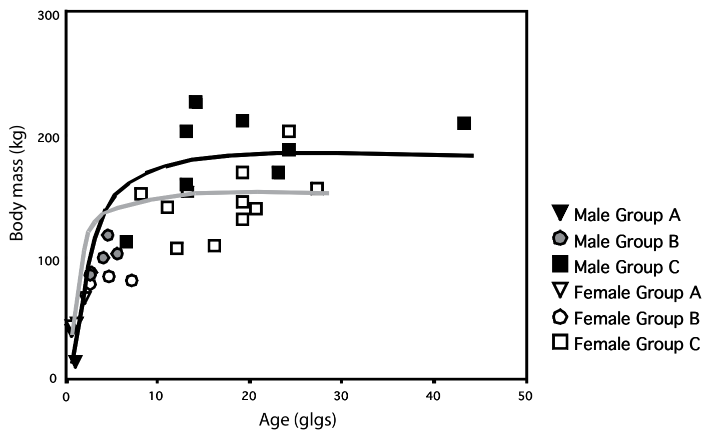


Figure 2. Scatterplot (with Gompertz curve) of age (growth layer groups) versus body weight (kg) of Age Groups A, B, and C for male and female bottlenose dolphins from the northwestern Gulf of Mexico

being normal or abnormal. All histological sections were examined using a Nikon Optiphot-2 microscope with a top-mounted, 35-mm Nikon camera. Any samples deemed abnormal (having pathologies) during histological examination were removed from the present study.

Data Analysis

Gompertz growth curves were fitted to size-at-age data using nonlinear, least-squares techniques. In the present study,

$$S = A(\exp(-b \exp(-kt)))$$

where, S is a measure of size, A is the symptotic value, b is the constant of integration, k is the growth rate constant, and t is age in GLGs (Fitzhugh, 1975; Read et al., 1993). Separate equations were derived for the two measures of size (SBL and BM) and for each sex.

Pearson's correlation coefficients were calculated among SBL, age, and various organ weights, including lungs, adrenal glands, kidneys, testes, ovaries, as well as the heart, liver, pancreas, brain, pituitary, thyroid, thymus, and spleen. Correlation coefficients between paired organs (left and right) also were calculated for lungs, adrenal glands, kidneys, testes, and ovaries. Analysis of variance (ANOVA) tests were conducted to determine whether animals exhibited significant sexual dimorphism in SBL, BM, or individual organ weights and functional symmetry in pared organs. A significance value of 0.05 was utilized for both Pearson's correlation and ANOVA tests. All statistical analyses were performed using *SPSS for Windows, Version 11.5.0*.

Multivariate analysis of variance (MANOVA), ANOVA, and subsequent Tukey's HSD test were

Table 1. Parameter values ± standard errors (SE) for Gompertz growth models derived from body size morphometric data for bottlenose dolphins from the present study using nonlinear, least-squares techniques where A is the symptotic value, b is the constant of integration, and k is the growth rate constant. Separate equations were derived for the two measures of size (length and mass) and for each sex (combined and individually).

Growth model	A ± SE	b ± SE	k ± SE
Combined length (cm)	249.46 ± 3.90	0.75 ± 0.07	0.35 ± 0.05
Female length (cm)	243.55 ± 4.31	0.73 ± 0.08	0.34 ± 0.07
Male length (cm)	257.53 ± 6.66	0.77 ± 0.13	0.33 ± 0.08
Combined mass (kg)	176.21 ± 11.51	1.48 ± 0.28	0.19 ± 0.06
Female mass (kg)	165.92 ± 20.57	1.25 ± 0.26	0.14 ± 0.06
Male mass (kg)	199.49 ± 11.21	1.92 ± 0.43	0.24 ± 0.07

conducted on published data of organ weights (heart, lungs, liver, l. kidney, r. kidney, spleen) from two species of delphinid: *Stenella graffmani* (now *S. attenuatta*) and *S. longirostris* from Perrin & Roberts (1972).

Results

Animals that died from unknown causes and animals that died from human interactions did not have significantly different organ weights (Anova, all $p \geq 0.05$); ovaries were not tested due to lack of data. Therefore, it appears that the organ weights in the present study were representative of a normal population of bottlenose dolphins regardless of the cause of death.

Growth

Ages of animals in the present study ranged from neonates (< 1 y) to 43 y of age, and growth curves (age vs SBL; age vs BM) were produced using these data (Table 1, Figures 1 & 2). Gompertz nonlinear models provided a representation of growth of bottlenose dolphins from the northwestern GOM in both measurements of body size and sex. Models were produced for SBL and BM in both male and female groups in addition to a model including all animals (Table 1).

Table 2. Summary statistics of standard body length (SBL), body mass (BM), age, and organ weights of bottlenose dolphins from the present study grouped by body size parameters A, B, and C as previously defined

	Group A (≤ 175 cm)			Group B (175-225 cm)			Group C (> 225 cm)		
Organ	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*
SBL (cm)	143.6	25.7	7	201.7	12.7	20	249.6	15.6	36
BM (kg)	44.5	16.9	6	91.5	19.1	17	166.3	42.0	30
Age (glg)	1.0	0.6	6	3.9	1.7	9	18.1	8.0	20
L. adrenal (g)	2.6	1.2	7	6.3	1.9	19	11.3	3.3	36
R. adrenal (g)	2.5	1.2	7	6.0	1.5	17	11.5	3.8	36
Brain (g)	909.1	151.9	6	1,332.2	105.3	13	1,471.7	115.3	27
Heart (g)	262.8	78.3	6	452.1	97.7	18	940.3	223.9	36
L. kidney (g)	137.9	66.2	7	309.7	108.2	17	611.8	134.4	35
R. kidney (g)	158.1	80.6	6	306.0	112.3	15	597.5	137.8	34
Liver (g)	978.3	535.8	7	2,546.9	1,141.4	18	4,304.5	1,384.1	33
L. lung (g)	623.8	279.1	7	1,204.3	519.6	18	2,872.9	900.9	34
R. lung (g)	722.6	394.6	7	1,338.1	553.5	18	3,235.8	970.7	33
L. ovary (g)	1.5	--	1	2.7	1.0	5	12.3	9.7	10
R. ovary (g)	1.7	--	1	2.3	0.8	5	6.3	2.5	10
Pancreas (g)	134.1	120.9	4	209.9	74.7	13	364.2	138.9	21
Pituitary (g)	0.8	0.2	4	1.1	0.4	11	2.1	0.5	18
Spleen (g)	60.8	42.7	5	73.4	31.5	17	92.9	44.4	34
L. testis (g)	3.1	1.1	2	16.0	5.5	11	439.2	310.6	15
R. testis (g)	2.9	0.9	2	15.7	5.8	11	443.2	308.9	15
Thymus (g)	71.1	55.2	5	39.0	19.7	4	41.5	12.5	5
Thyroid (g)	20.3	7.0	4	26.6	5.6	10	34.1	11.8	24

Table 3. Correlation coefficients of organ weights with standard body length (SBL), body mass (BM), and age (in GLGs) for bottlenose dolphins from the present study; bolded values are $p < 0.05$.

Variable	Group	Age	L. adrenal	R. adrenal	Brain	Heart	L. kidney	R. kidney	Liver	L. lung	R. lung
SBL	All	**0.707**	**0.758**	**0.699**	**0.824**	**0.848**	**0.865**	**0.859**	**0.761**	**0.800**	**0.812**
	A	0.428	**0.855**	**0.876**	**0.875**	**0.823**	**0.885**	**0.850**	**0.870**	**0.978**	**0.988**
	B	**0.754**	**0.598**	**0.589**	0.308	**0.634**	0.447	0.513	**0.528**	**0.644**	**0.576**
	C	0.171	0.147	-0.002	0.218	**0.488**	**0.537**	**0.580**	**0.400**	**0.427**	**0.441**
BM	All	**0.783**	**0.715**	**0.674**	**0.736**	**0.923**	**0.859**	**0.861**	**0.778**	**0.840**	**0.869**
	A	0.534	**0.883**	**0.846**	0.658	**0.965**	**0.954**	**0.921**	**0.963**	**0.836**	**0.894**
	B	0.170	0.051	0.202	0.474	**0.568**	**0.636**	**0.687**	**0.532**	**0.586**	0.515
	C	0.439	0.252	0.153	0.092	**0.808**	**0.567**	**0.575**	**0.533**	**0.578**	**0.650**
Age	All	--	**0.725**	**0.790**	**0.490**	**0.857**	**0.805**	**0.837**	**0.828**	**0.837**	**0.834**
	A	--	0.681	0.776	0.134	0.540	0.627	0.764	0.596	0.512	0.575
	B	--	0.669	0.714	0.503	0.443	0.089	-0.058	0.110	0.295	0.419
	C	--	0.283	0.489	-0.289	**0.629**	0.267	0.395	**0.631**	**0.598**	**0.556**

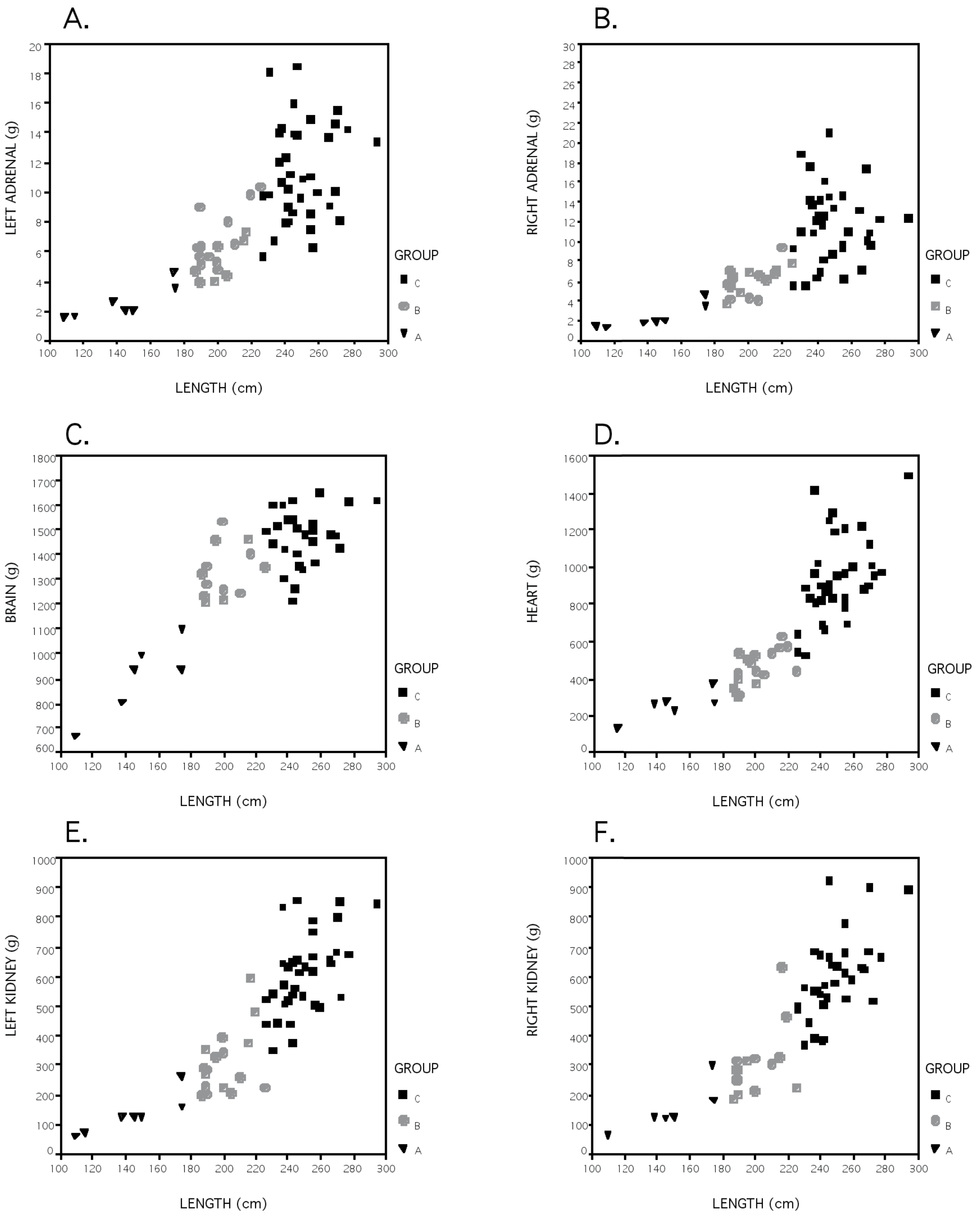
Variable	Group	L. ovary	R. ovary	Pancreas	Pituitary	L. testis	R. testis	Spleen	Thymus	Thyroid
SBL	All	**0.537**	**0.562**	**0.704**	**0.699**	**0.726**	**0.710**	0.250	-0.294	**0.493**
	A	--	--	0.909	0.202	**1.000**	**1.000**	0.652	0.013	0.710
	B	0.352	0.231	0.530	0.277	**0.770**	**0.633**	0.096	0.942	**0.670**
	C	0.268	-0.414	0.421	0.017	0.491	**0.607**	0.149	-0.273	0.148
BM	All	0.465	**0.721**	**0.699**	**0.619**	**0.886**	**0.880**	0.274	-0.266	**0.526**
	A	--	--	0.794	0.420	**1.000**	**1.000**	**0.884**	0.102	0.895
	B	0.986	0.995	0.574	0.529	**0.695**	0.525	**0.772**	0.445	0.455
	C	0.161	0.447	0.410	-0.379	**0.795**	**0.923**	-0.080	-0.556	0.084
Age	All	0.126	0.349	**0.711**	**0.489**	**0.778**	**0.764**	0.507	-0.396	0.315
	A	--	--	0.559	-0.574	**1.000**	**1.000**	0.820	-0.286	-0.200
	B	**1.000**	**1.000**	0.006	-0.414	**0.853**	0.343	0.165	--	0.800
	C	-0.271	-0.250	0.206	-0.204	0.492	0.468	**0.459**	-0.392	-0.102

Sexual Dimorphism

Overall, SBL and BM were not significantly different between the male and female bottlenose dolphins (age groups combined) included in the present study (ANOVA, all $p > 0.05$); however, SBL was found to be significantly greater in males (256.7 ± 17.6 cm) than in females (241.7 ± 7.5 cm) within mature dolphins (Age Group C: ANOVA, $F_{1,34} = 10.465$ $p = 0.003$). SBL was not significantly different between the sexes in neonatal and juvenile animals (Age Groups A & B), and BM was not significantly different between the sexes in any group. Organ weights were not significantly different between all male and female bottlenose dolphins included in the present study, including individual analyses of all age groups (ANOVA, all $p > 0.05$).

Correlations

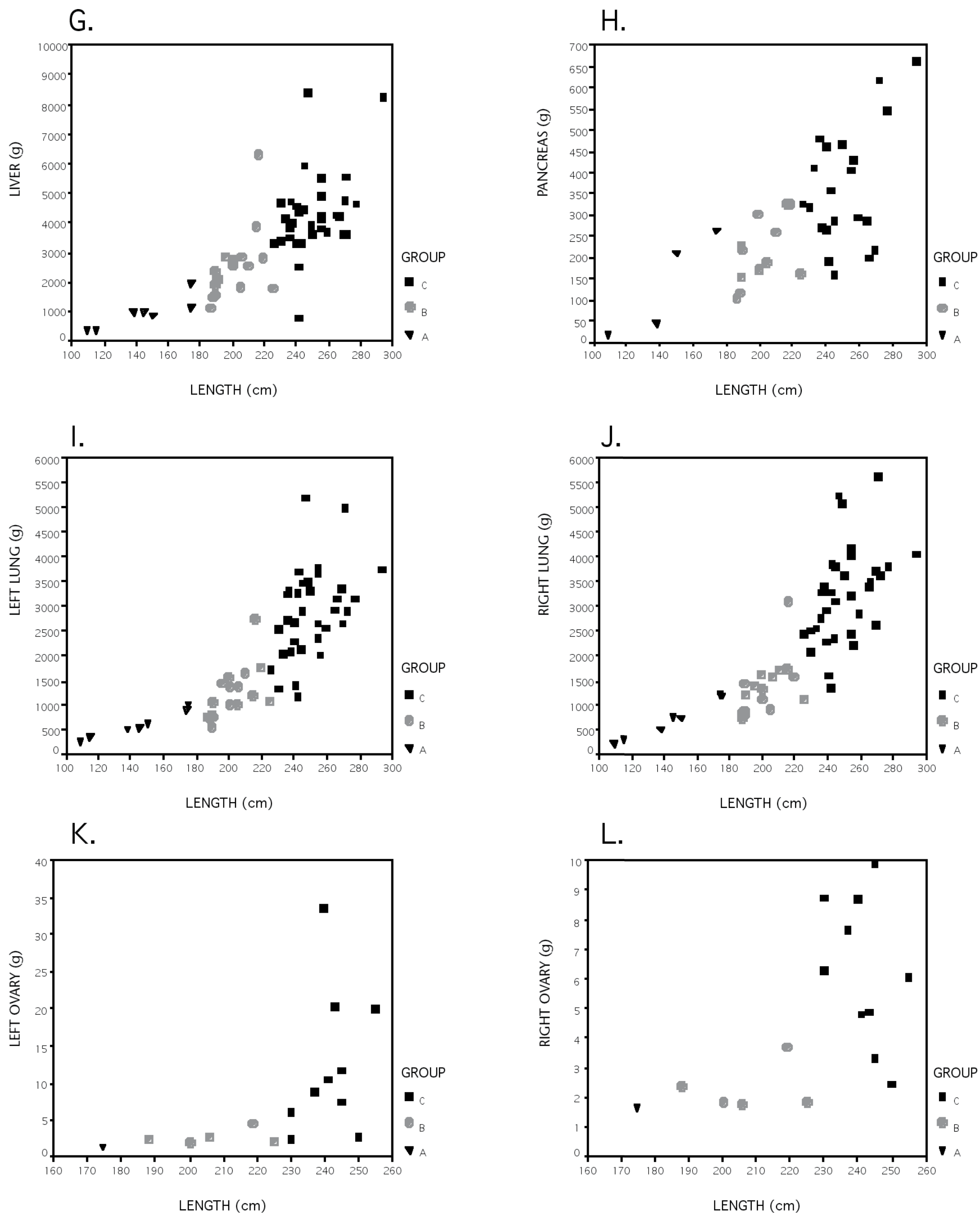
SBL, BM, age (in GLGs), and organ weights were summarized for individuals within each previously defined age group and are presented in Table 2. When all animals were included in the analyses, SBL was significantly correlated with age (r = 0.707) as well as BM (r = 0.783; Table 3). All organ weights (except for thymus and spleen) were significantly correlated with SBL (Table 3). Similar results were obtained with BM as all organ weights except the left ovary, spleen, and thymus were significantly correlated; however, age was significantly correlated with all organs except the thymus, thyroid, and both left and right ovaries. Organ weights within individual age groups were not as strongly correlated with SBL, BM, or age as when all animals were combined (Figures 3A-R). Individuals from Group A had pancreas, thymus, and thyroid organ weights significantly correlated with both SBL and BM, while only testes weights were correlated with age. Individuals from Group B had heart, liver, left lung, and left testis weights significantly correlated with SBL and BM, while only the left testis and left and right ovary weights were significantly correlated with age. Individuals from Group C had the least degree of correlation



Figures 3A-F. Scatterplots of organ weight (g) versus standard body length (cm) of bottlenose dolphins from the present study, including A. left adrenal gland, B. right adrenal gland, C. brain, D. heart, E. left kidney, and F. right kidney; age classes (A, B, and C) are those defined in text.

among SBL, BM, and weights of the heart, kidneys, liver, lungs, and testes, while only the right adrenal gland, heart, liver, lungs, and spleen weights correlated significantly with age.

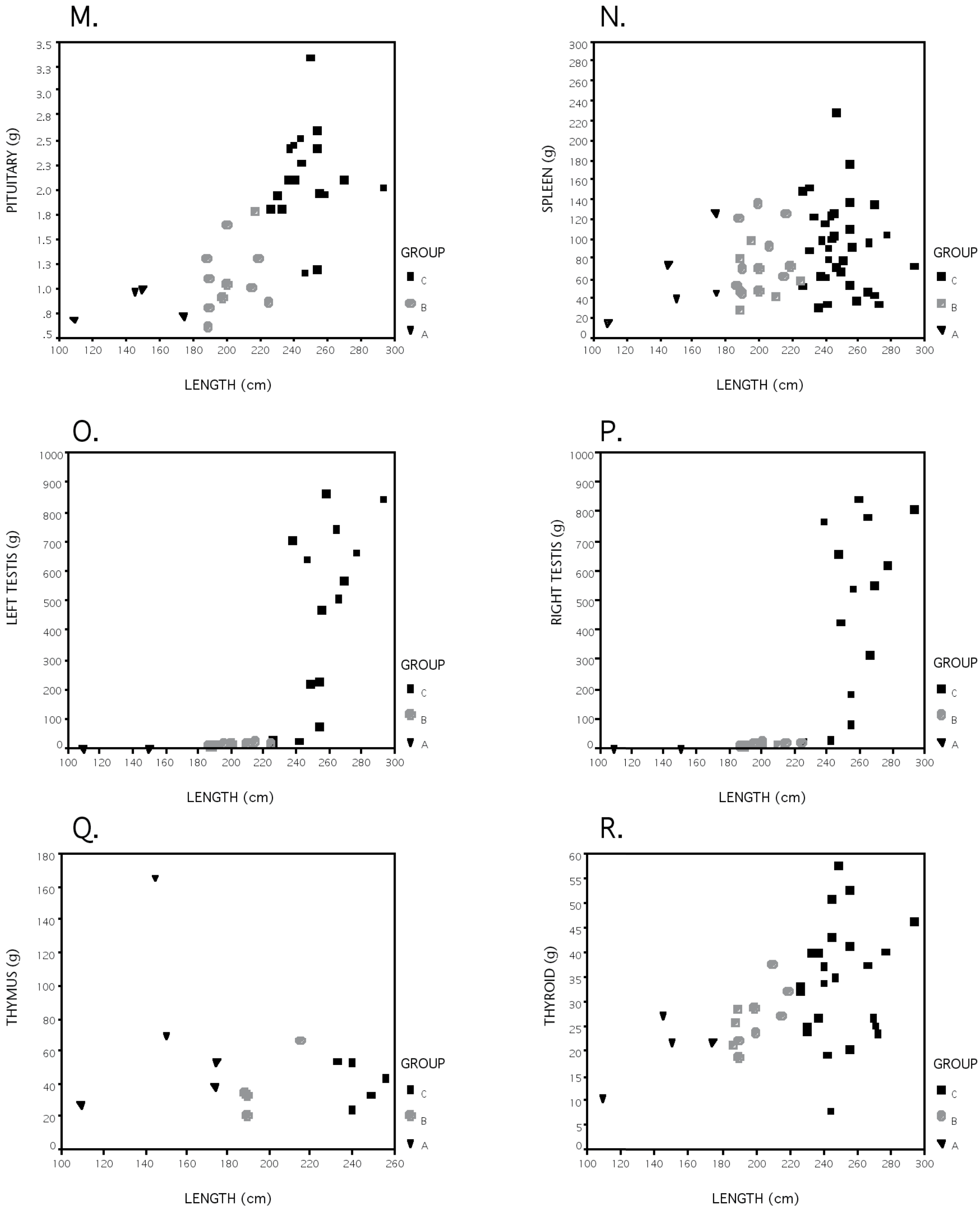
All paired organs were significantly correlated in bottlenose dolphins included in the present study grouped by body size, with the exception of ovaries in Group C (Table 4).



Figures 3G-L. Scatterplots of organ weight (g) versus standard body length (cm) of bottlenose dolphins from the present study, including G. liver, H. pancreas, I. left lung, J. right lung, K. left ovary, and L. right ovary; age classes (A, B, and C) are those defined in text.

Asymmetry of Paired Organs

Results indicated that weights of paired organs (adrenal glands, kidneys, lungs, ovaries, testes) were not significantly different in individual bottlenose dolphins analyzed in the present study (Table 5); however, individual paired organs may weigh up to 95% more than the corresponding organ with the degree and direction of asymmetry varying widely by organ. In four of the five paired organs (adrenal glands, kidneys, ovaries, and testes), the left side exhibited a greater weight.



Figures 3M-R. Scatterplots of organ weight (g) versus standard body length (cm) of bottlenose dolphins from the present study, including M. pituitary gland, N. spleen, O. left testis, P. right testis, Q. thymus, and R. thyroid; age classes (A, B, and C) are those defined in text.

Organ Weights Among Delphinids

Correlation coefficients and percent organ weight of BM for *T. truncatus* from the GOM were compared to published values for *S. attenuatta* and *S. longirostris* in the Pacific using a subset of organ weights examined by Perrin & Roberts (1972) (Table 6). Significant differences were identified among the three species in regard to percent organ weight of BM (MANOVA, $F_{12,152} = 8.436$, $p < 0.001$). Univariate tests further revealed that of the six organs tested, there was no significant difference in the proportion of heart and lung weight

Table 4. Correlation coefficients of paired organ weights for bottlenose dolphins from the present study grouped by body size parameters A, B, and C as previously defined; all $p < 0.05$.

Organ	Group	r
Adrenals	All	0.943
	Group A	0.974
	Group B	0.875
	Group C	0.878
Kidneys	All	0.940
	Group A	0.992
	Group B	0.976
	Group C	0.772
Lungs	All	0.972
	Group A	0.979
	Group B	0.927
	Group C	0.927
Ovaries	All	0.583
	Group A	--
	Group B	0.929
	Group C	0.320**
Testes	All	0.982
	Group A	1.000
	Group B	0.827
	Group C	0.785

** not correlated

Table 5. Asymmetry of paired organ weights within bottlenose dolphins from the present study

Paired organ	% difference in weight (g)	Larger side	% frequency	*n*
Adrenals	12.8 ± 11.8	Left	61.6	60
Kidneys	8.2 ± 15.4	Left	52.8	55
Lungs	15.3 ± 14.7	Right	84.7	58
Ovaries	95.9 ± 106.9	Left	80.0	16
Testes	21.0 ± 37.4	Left	55.1	29

to body weight among the three species, while the percent weight of liver, left kidney, right kidney, and spleen (ANOVA, all $p < 0.05$). Tukey's HSD tests indicated that proportional organ weights of the kidneys and spleen were more similar between *T. truncatus* and *S. longirostris* than between *S. longirostris* and *S. attenuatta*.

Discussion

Age classes used in the present study were based on the developmental growth curves of these animals and were similar to those defined in previous studies of *Tursiops truncatus* (Read et al., 1993; Fernandez & Hohn, 1998; Turner, 1998; Turner & Worthy, 2003), other delphinids (Perrin et al., 1976, 1977), and odontocetes (Doidge, 1990; Read & Gaskin, 1990). Dolphins in the present study exhibited asymptotic values of length, which were comparable to those calculated from a previous study of *T. truncatus* from a coastal Texas population (Fernandez & Hohn, 1998); however, both female and male dolphins in the present study had smaller asymptotic values of SBL and BM than animals from the Gulf coast of Florida (Read et al., 1993). Individuals in the present study were shorter and had smaller BM. SBL of dolphins in the present study also were compared with animals included in a study examining the morphometric variability in *T. truncatus* from both Texas and Florida GOM populations. Results indicated that the dolphins from the present study are morphometrically similar to those from coastal Texas populations and are smaller than those presumed to belong to the larger "offshore" ecotype (Turner, 1998).

Bottlenose dolphins in the present study did not exhibit sexual dimorphism in measures of SBL and BM when all groups were combined, although male dolphins from Age Group C (i.e., mature males) were significantly larger. This is similar to results obtained from previous studies, indicating that sexual dimorphism in SBL of bottlenose dolphins does not occur until physical maturation (Sergeant et al., 1973; Hohn, 1980; Kasuya et al., 1986; Cockroft & Ross, 1990; Read et al., 1993). BM of *T. truncatus* included in the present study were not sexually dimorphic, however, regardless of age, which is similar to results from the Atlantic Coast of the United States (Mead & Potter, 1990), but differs from the results of previous studies from coastal South Africa (Cockroft & Ross, 1990) and Florida (Read et al., 1993), where males have considerably greater BM than females (26% and 11%, respectively).

Sexual dimorphism was not identified in weights of any of the organs assessed in the present study. Information on sexual dimorphism in individual organ weights of *T. truncatus*, as well as other delphinids, is limited at best. We compared published data from a previous study of the organ weights of two species of *Stenella* (Perrin & Roberts, 1972), which indicated that sexual dimorphism was not present in the seven organs they examined (heart, lungs, liver, kidneys, and spleen), including all age groups. Therefore, from the limited amount of data available, it appears that sexual dimorphism is not present in the organ weights of *T. truncatus* nor in at least two other similar delphinids, regardless of age group.

Allometric relationships between organ weight and BM were similar to those described for other mammalian species (Schmidt-Nielsen, 1984). Weak correlations between age and most organ weights observed in the present study is consistent with previous work reported by Cowan

Table 6. Correlation coefficient (r) and average percent of body mass (BM) for bottlenose dolphins from the present study compared with data by Perrin & Roberts (1972) on *Stenella attenuata* and *S. longirostris*; age groups for *Tursiops* were defined herein and applied to data on *Stenella*. Bold values are significant at the $\alpha = 0.05$ level.

		T. truncatus			*S. attenuatta*			*S. longirostris*		
Organ	Age group	r SBL	r BM	Ave % BM ± SD	r SBL	r BM	Ave % BM ± SD	r SBL	r BM	Ave % BM ± SD
Heart	All	**0.85**	**0.92**	0.55±0.07	**0.97**	**0.97**	0.51±0.12	**0.93**	**0.94**	0.51±0.06
	Group A	**0.82**	**0.97**	0.58±0.05	**0.90**	**0.92**	0.75±0.06	0.84	0.93	0.56±0.03
	Group B	**0.63**	**0.57**	0.51±0.08	**0.81**	**0.92**	0.48±0.04	0.97	0.97	0.58±0.04
	Group C	**0.49**	**0.81**	0.56±0.07	0.55	**0.65**	0.42±0.05	0.12	0.54	0.46±0.05
L. kidney	All	**0.87**	**0.86**	0.36±0.07	**0.88**	**0.92**	0.45±0.09	**0.79**	**0.74**	0.34±0.10
	Group A	**0.89**	**0.95**	0.34±0.04	**0.93**	**0.90**	0.53±0.05	0.90	0.94	0.32±0.02
	Group B	0.45	**0.64**	0.33±0.07	**0.79**	**0.82**	0.44±0.10	0.96	0.97	0.31±0.02
	Group C	**0.54**	**0.57**	0.38±0.07	**0.78**	**0.71**	0.46±0.07	-0.05	-0.30	0.36±0.15
R. kidney	All	**0.86**	**0.86**	0.36±0.07	**0.88**	**0.92**	0.48±0.10	**0.79**	**0.74**	0.36±0.10
	Group A	**0.85**	**0.92**	0.35±0.06	0.52	0.50	0.56±0.11	**0.95**	**0.85**	0.36±0.02
	Group B	0.51	**0.69**	0.33±0.07	**0.77**	**0.82**	0.46±0.09	0.79	0.81	0.36±0.03
	Group C	**0.58**	**0.58**	0.38±0.07	**0.76**	**0.72**	0.48±0.08	-0.11	-0.31	0.37±0.14
Liver	All	**0.76**	**0.78**	2.61±0.75	**0.92**	**0.95**	2.28±0.36	**0.95**	**0.93**	1.97±0.25
	Group A	**0.87**	**0.96**	2.39±0.26	0.67	**0.75**	1.84±0.27	**0.98**	0.88	1.98±0.14
	Group B	**0.53**	**0.53**	2.73±0.96	**0.82**	**0.93**	2.34±0.30	0.85	0.86	2.17±0.25
	Group C	**0.40**	**0.53**	2.60±0.69	**0.56**	**0.50**	2.37±0.37	-0.22	0.26	1.84±0.22
Lungs	All	**0.73**	**0.81**	3.26±1.00	**0.97**	**0.99**	3.57±0.55	**0.95**	**0.99**	3.27±0.13
	Group A	**0.99**	**0.88**	3.24±0.66	0.67	**0.76**	4.92±0.65	**1.00**	**1.00**	3.35±0.05
	Group B	0.29	0.43	2.57±1.05	**0.88**	**0.95**	3.41±0.26	**1.00**	**1.00**	3.26±0.15
	Group C	**0.49**	**0.63**	3.66±0.82	0.68	0.71	3.19±0.31	--	--	--
Spleen	All	0.25	0.27	0.07±0.03	**0.58**	**0.51**	0.09±0.04	0.14	0.19	0.07±0.04
	Group A	0.65	**0.88**	0.13±0.04	0.58	0.60	0.07±0.02	0.46	0.63	0.11±0.04
	Group B	0.10	**0.77**	0.08±0.02	**0.35**	**0.48**	0.11±0.03	0.25	0.27	0.08±0.03
	Group C	0.15	-0.08	0.06±0.03	0.33	0.31	0.06±0.01	0.17	0.74	0.04±0.01

(1966) on pilot whales (*Globicephala melaena*). Additionally, Cowan reported that all non-endocrine organs were correlated with SBL (and BM through indirect calculations). During the exponential phase of the growth curve, it appears that SBL can be used as a relatively accurate measurement of age, although the phase of negative growth acceleration does not yield an accurate relationship. Therefore, data from the present study reveals that SBL is not a reliable indicator of age estimation in sexually mature animals. Results indicate that paired organs in bottlenose dolphins are significantly correlated, except for the ovaries in mature females. Data from *T. truncatus* and other related species were not available for comparison, making it difficult to determine if this feature is common in other delphinids.

Data from the present study indicated that weights of paired organs in individual *T. truncatus* were not significantly different, including adrenal glands, kidneys, lungs, ovaries, and testes. Similar results were identified in the kidneys of *S. attenuatta* and *S. longirostris* as no significant differences were identified; however, in both *T. truncatus* from the present study and *Stenella* spp. from a previous study (Perrin & Roberts, 1972), it appears that a large degree of variability exists between paired organs within individuals. For example, in both *S. attenuatta* and *S. longirostris,* the right kidney was often heavier, typically by 2 to 4%. Similar results were identified in kidneys of *T. truncatus*, although all other paired organs (adrenal glands, lungs, testes, and ovaries) exhibited a much larger degree of asymmetry (12.8%, 15.3%, 21.0%, and 95.9%, respectively). Furthermore, contrary to results from the study examining kidneys in *Stenella* spp., the left side of most paired organs in the present study were heavier.

Correlation coefficients and the percent of organ weight of BM for *T. truncatus* from the GOM compared to published values for *S. attenuatta* and *S. longirostris* in the Pacific revealed a similarity across all three species, indicating that the overall relationships among SBL, BM, age, and organ weights may be inherent among these three delphinids; however, significant differences were identified among the three species in regard to the percent of organ weight demonstrating that although allometric relationships among species were similar, specific weights of individual organs were different. It is unknown whether these differences relate to similarities in life history patterns or physiological parameters between *T. truncatus* and *S. longirostris* or whether the differences between *S. longirostris* and *S. attenuatta* are a function of a large degree of variability within the *Stenella* genus.

The causes of stranding and/or death of animals in the present study varied and usually involved several factors. Thirteen of the 63 (20.6%) animals had evidence of severe trauma; nine of these 13 animals stranded/died due to human interaction (net entanglement, boat collision, or entanglement in fishing gear), two of the animals stranded/died due to intraspecific aggression, and two animals stranded/died from nontrauma-related causes. The remaining 50 bottlenose dolphins stranded/died from apparently natural causes or diseases. Since a stranded animal may not show signs of chronic disease or illness, we compared organ weights from human interaction vs natural causes or diseases and found that, with the exception of the lungs, diseases or pathologies observed in the present study did not significantly alter the weight of the organs.

Data on organ weights of bottlenose dolphins in the GOM, when correlated with SBL and age, offer an important tool for pathologists and veterinarians for aiding in interpretation of health status. In general, it appears that dolphins that died from unknown causes and animals that died from human interactions did not have significantly different organ weights and, therefore, the organ weights presented here represent a normal population of bottlenose dolphins. Additionally, a special note should be made for two specific organs in bottlenose dolphins from the western GOM: lungs and thymus. First, we have described a previously unrecognized lung disease, angiomatosis, in *T. truncatus* within the GOM coastal area, which increased in both incidence and severity over the course of the study period (Turnbull & Cowan, 1999). In its less advanced stage, lungs with this disease are indistinguishable from lungs without the disease on the basis of weight, while the heaviest lungs all have the advanced disease. Second, because of the location of the thymus (intimately related to the vessels of the aortic arch) and its involution with age, thymus weights are less accurate in older animals (Clark et al., 2005). In calves, it is easy to identify and collect the entire gland; however, in adults, the thymus softens and becomes progressively more indistinct, making complete removal problematic. Furthermore, in many animals, the thymus often develops large cysts, making weight disproportionately large (Cowan, 1994). Although no significant differences were detected in lung or thymus weights between animals that died from unknown causes and animals that died from human interactions, caution should be used in interpreting lung and thymus weights included in the present study for reasons previously stated.

In summary, dolphins included in the present study were thought to belong to the coastal Texas population and were smaller and had less BM than similarly aged animals from Florida. Sexual dimorphism was not present in *T. truncatus* from the present study when all groups were combined, although male dolphins from Group C were significantly larger. BM of *T. truncatus* included in the present study were not sexually dimorphic, regardless of age, which differs from the results of some previous studies. Additionally, sexual dimorphism was not identified in weight of any of the organs assessed in the present study, which is comparable to results found in similar delphinids. Allometric relationships between organ weight and BM were similar to those described for other mammalian species, and data from the present study reveal that SBL is not a reliable indicator of age estimation in sexually mature animals. Finally, results indicate that paired organs in bottlenose dolphins are significantly correlated, except for ovaries in mature females, and that no paired organs had significantly different weights.

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