NOAA Technical Memorandum NMFS-AFSC-312
doi:10.7289/V5/TM-AFSC-312

California Sea Lion Sex- and Age-specific Morphometry

by
J. L. Laake, S. R. Melin, A. J. Orr, D. J. Greig,
K. C. Prager, R. L. DeLong, and J. D. Harris

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Alaska Fisheries Science Center

January 2016

NOAA Technical Memorandum NMFS

The National Marine Fisheries Service's Alaska Fisheries Science Center uses the NOAA Technical Memorandum series to issue informal scientific and technical publications when complete formal review and editorial processing are not appropriate or feasible. Documents within this series reflect sound professional work and may be referenced in the formal scientific and technical literature.

The NMFS-AFSC Technical Memorandum series of the Alaska Fisheries Science Center continues the NMFS-F/NWC series established in 1970 by the Northwest Fisheries Center. The NMFS-NWFSC series is currently used by the Northwest Fisheries Science Center.

This document should be cited as follows:

Laake, J. L., S. R. Melin, A. J. Orr, D. J. Greig, K. C. Prager, R. L. DeLong, and J. D. Harris. 2016. California sea lion sex- and age-specific morphometry. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-312, 21 p. http://dx.doi.org/10.7289/V5/TM-AFSC-312.

http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-312.pdf

NOAA Technical Memorandum NMFS-AFSC-312
doi:10.7289/V5/TM-AFSC-312

California Sea Lion Sex- and Age-specific Morphometry

by
J. L. Laake[1], S. R. Melin[1], A. J. Orr[1], D. J. Greig[2], K. C. Prager[3,4],
R. L. DeLong[1], and J. D. Harris[1]

[1]Alaska Fisheries Science Center
National Marine Mammal Laboratory
7600 Sand Point Way NE
Seattle, WA 98115

[2]California Academy of Sciences
55 Music Concourse Drive
San Francisco, CA 94118

[3]Department of Ecology and Evolutionary Biology
University of California
Los Angeles, CA 90095

[4]Fogarty International Center
National Institutes of Health
Bethesda, MD 20892

U.S. DEPARTMENT OF COMMERCE
Penny. S. Pritzker, Secretary
National Oceanic and Atmospheric Administration
Kathryn D. Sullivan, Under Secretary and Administrator
National Marine Fisheries Service
Eileen Sobeck, Assistant Administrator for Fisheries

January 2016

This document is available to the public through:

National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

www.ntis.gov

ABSTRACT

Pinnipeds are primarily aged by marks (e.g., flipper tags, brands) applied to individuals when they are of known age (e.g., pups). Age determination is useful for researchers and managers for various reasons including estimating survival rates and assessing mortality of individuals that interact with fisheries. Age can be determined from unmarked animals by extracting a tooth and counting the number of dentine layers. For most populations, however, relatively few individuals are marked and it is often impractical to extract a tooth. Here we developed sex-specific length-age and weight-age curves for the California sea lion (*Zalophus californianus*). Additionally, we fit a power law curve for an allometric relationship between length and weight. We obtained length and weight measurements from known-age California sea lions captured at various haulout or rookery sites on islands off California and locations in Oregon and Washington. Gompertz and Von Bertalanffy growth models were compared after fitting them to length-at-age (cm) and weight-at-age (kg) data for male and female sea lions from 1 month to age 16 years and 19 years, respectively. The length-at-age data included initial capture and recapture records of female (n = 8,035) and male (n = 5,813) sea lions. The Von Bertalanffy growth curve was a better model than the Gompertz for length- and weight-at-age for both males and females. The weight-at-age relationship was much more variable than for length due to the smaller sample size and the vagaries of seasonal and annual weight loss and gain. However, a linear relationship for weight for ages 3.5-8 months is very reasonable based on the fitted growth curve.

CONTENTS

Abstract iii

Introduction 1

Methods 2

Results 3

Length-at-Age Model 3

Weight-at-Age Model 4

Weight-Length Model 5

Discussion 6

Acknowledgments 7

Citations 9

Tables 11

Figures 18

INTRODUCTION

Research on the California sea lion (*Zalophus californianus*) has been conducted at the National Marine Mammal Laboratory (NMML) for over four decades. As part of that research, basic measurements of weight, length, and age (when known) were recorded when the animals were initially captured and marked or when they were recaptured. In addition, the private, non-profit Marine Mammal Center has been collecting baseline information on stranded sea lions for nearly 25 years (Greig et al. 2005). Collaborative research between NMML and the Lloyd-Smith laboratory at UCLA on leptospirosis provided additional measurements for juvenile sea lions. From these sources, we have compiled data to describe sex- and age-specific morphometry of California sea lions.

Pinnipeds are most commonly aged by marks (e.g., flipper tags, brands) applied when the animals are of known age (e.g., pups). For unmarked animals that are captured or found dead, age can be determined by the extraction of a tooth. The tooth has annual growth layers that can be counted like tree rings to determine the age of the animal at the time of death or capture (Hobson and Sease 1998, Childerhouse et al. 2004, Greig et al. 2005), although this method has not been validated in known-aged California sea lions. Only small numbers of animals in most populations are of known-age and it is not always possible to extract a tooth from live animals or recover a tooth from dead animals. In contrast, total body length is easily and commonly collected from live or dead animals. Therefore, establishing a species-specific length-age relationship that allows age estimation from total body length is a useful tool for researchers and managers.

A length-age relationship is a useful technique to estimate age for California sea lions (hereafter, sea lions) that are frequently captured for research or rehabilitation, or killed in fisheries each year (Caretta et al. 2013). Most of these animals are unmarked, but knowing the age of these animals is important to put the research or mortality into a life history or population context. For example, males of unknown age have been captured and branded in Washington and Oregon and an estimate of their age would enhance the analysis of their survival rates. Likewise, fishery-related mortality is an important component of determining the status of the sea lion population but this mortality needs to be apportioned into age classes to assess the effect of the mortality on the population. If juvenile animals are primarily entangled and killed, it will have a different effect on the population growth than if adults are entangled and killed. Similarly, mortality of prime-aged adult females will have a greater impact on overall population growth than will an equivalent mortality of adult males. Greig et al. (2005) estimated a length-age relationship of sea lions that stranded along the California coast using teeth and standard length but their sample of adults was small compared to pups and juveniles.

At San Miguel Island (SMI), California, a marking program for sea lions has been underway since 1975. Pups were tagged only up to 1987 and branded and tagged from 1987 to the present. Weights and lengths were taken when the pups were marked between early September and early November. Beginning in 1997, weights and lengths of a subsample of marked pups were taken to measure growth when the pups were approximately 7 months old. To achieve some consistency for comparison across years, a predicted average weight at 1 October has been computed for each year by fitting a mixed-effects linear model to the weight data over the span of ages from 3.5 to 8 months. The validity of that linearity assumption and the resulting adjusted estimates can be evaluated by examining a more complete weight growth curve across the entire data set.

Deviations from a weight-length curve can be used to evaluate body condition (e.g., body mass index for humans). We fitted a power law curve to the length and weight data and compared our analysis to the results of Silva (1998) who evaluated allometric relationships in mammals.

METHODS

We measured length and weight from marked sea lions of known age that have been captured or recaptured at various times for research purposes in California on San Miguel Island (SMI), San Nicolas Island (SNI), San Clemente Island (SCI) and Año Nuevo Island (ANI), and locations in Oregon and Washington (Astoria, Oregon, the Columbia River, and the Ballard Locks in Seattle). Although some older animals of known age have been recaptured, the majority of the data are from pups. To supplement these data with older sea lions, we used the data from Greig et al. (2005) who measured length and estimated age (by counting annular rings in canine teeth) of stranded sea lions.

Gompertz and Von Bertalanffy growth curves were fitted to length-at-age (cm) and weight-at-age (kg) data for male and female sea lions from 1 month to age 16 years and 19 years, respectively. The growth models were fitted using the nls function in R (R Core Team 2015) in conjunction with the FSA package (Ogle 2015) self-start functions SSGompertz for the Gompertz growth curve and vbFuns for the Von Bertalanffy. Akaike information criterion (AIC) (Burnham and Anderson, 2002) was used to select the better model between the Gompertz and the Von Bertalanffy growth curves. Parameter standard errors and 95% confidence intervals were computed from 1,000 non-parametric bootstraps.

The relationship between weight and length was also fitted to female and male data separately with the nls function using the equation: $\mathrm{W} = \mathrm{aL}^{\mathrm{b}}$ where *W* is weight in kg, *L* is length in cm, *a* is the slope and *b* is the exponent (power). As with the above, the standard errors and 95% confidence intervals were computed from 1000 non-parametric bootstraps. To evaluate our results from the weight-length data to mammalian allometric relationships of length and weight (Silva 1998), we similarly fitted a major axis regression with the R package lmodel2 (Legendre 2014) on log10(weight) to predict log10(length) after converting length from cm to mm.

RESULTS

Length-at-Age Model

The length-at-age (years) data included initial capture and recapture records of female (n = 8,035) and male (n = 5,813) sea lions on the Channel Islands and along the west coast. There were 13,215 records from SMI, 610 from SNI, and the remainder from locations along the west coast, which were all from non-pups. In addition, length data from 173 female and 90 male stranded sea lions were used (Greig et al. 2005).

The Von Bertalanffy growth curve was the better model than Gompertz for length-at-age with ΔAIC = 100.0 and 143.3 for female and male sea lions, respectively (Fig. 1). The Von Bertalanffy growth curve equation is $L = L_{inf}(1 - e^{-k(t-t_0)})$, where *L* is length in cm, *t* is age in years, L_{inf} is the asymptotic length, *K* controls the growth rate and t_0 is defined to be the age at which length is 0. Table 1 contains the sex-specific parameter estimates, standard errors and confidence intervals. The percentage of explained deviance was 75.3 and 74.6 for females and males, respectively. At each age t, the proportion of the asymptotic length is $(1 - e^{-k(t-t_0)})$. For example, at birth (t = 0), female pups are 49.6% of their asymptotic length whereas male pups are at only 37%. Females reach 90% of their asymptotic length by age 4 whereas males do not reach it until age 11.

The predicted length at $t = 0$, was 81 cm for females and 85 cm for males and the average length of pups 10 days old and younger was 73.7 cm (SE = 0.48, n = 79) and 78.3 cm (SE = 0.38, n = 113) for females and males, respectively, suggesting a lack of model fit for ages close to birth. The lack of fit is also reflected in the estimate of t_0 which is 1.67 and 2.57 years prior to birth which is clearly unrealistic. This lack of fit may be due to low sample sizes for younger ages (n = 192) and a year bias as all but seven of these data points were from 2007. However, despite this apparent lack of fit for younger animals, overall the model fit the data reasonably well with deviations between predicted and observed values that ranged between -1.7% and 6.1% (Table 2).

Prediction of age from length can be useful to assign an age to fisheries entangled sea lions where only sex and length are recorded. However there is a considerable amount of variability in the length-at-age and we found that length data could only be useful in accurately predicting the following broader age categories: pups, 1-2 years old, and ≥ 3 years old (Table 3). This is particularly true for females as they reach their asymptotic length at a younger age than males. Because males do not reach 90% of their asymptotic length until 11 years old, an additional age class of ≥ 8 years may be appropriate and useful in aging males of unknown age but known length. For males, 80% (40 of 50) of the 8-year-olds were 198 cm or longer and only 4.8% (2 of 42) of 3-7 year old males exceeded 198 cm. This provides a rough approximation to age for survival analysis of males of unknown age but known length.

Weight-at-Age Model

For weight-at-age models, the data included initial capture and recapture records of female (n = 10,586) and male (n = 8,102) sea lions on the Channel Islands and along the west coast. There were 17,829 records from SMI, 782 from SNI, 50 from SCI, which were mostly pups and the remainder from locations along the west coast, which were all non-pups.

The Von Bertalanffy growth curve was the better model than Gompertz for weight-at-age with ΔAIC = 553.9 and 312.2 for females and males, respectively (Fig. 2). The growth curve equation is $W = W_{inf}(1 - e^{-k(t-t_0)})$, where *W* is weight in kg, *t* is age in years, W_{inf} is the asymptotic weight, *K* controls the growth rate and t_0 is defined to be the age when weight is 0. Sample sizes for non-pups were low because obtaining weights of wild-caught non-pups in the field is physically and logistically difficult and stranded animals had to be excluded from the analysis as the weights of these ill or injured animals would not be representative of the healthy free-ranging population. In addition to small sample size for non-pups, variability in the data, as seen in the wide 95% confidence intervals and large values for standard error, was greater (Table 4). The percentage of explained deviance for the fitted models was 50.9 and 77.2, for females and males, respectively. The values for the calculated percent deviation between predicted and observed means by age were greater for weight than for length, and the differences was most apparent in the older age classes with small sample sizes (Tables 2, 5).

A linear model was fitted to the predictions of the Von Bertalanffy growth model for ages 3.5 to 8 months to assess validity of using a linear model for this age range (Fig. 3). The maximum absolute difference between linear approximation and the Von Bertalanffy model was 0.053 kg for females and 0.015 kg for males.

Weight-Length Model

The power law relationship between weight and length ($W = aL^b$) has been called the cube law in fisheries and is based on the assumption that the exponent b = 3 (Froese 2006). For sea lions, the exponent was approximately 2.8 for both sexes (Table 6). Using the method described in Silva (1998) and combining the sexes, the slope for log10(weight) was 0.291 (95% confidence interval: 0.288-0.293) and the intercept was 2.605 (95% confidence interval: 2.603-2.609; Fig. 4). These results are consistent with those of Silva (1998) who found a slope of 0.271 (confidence interval: 0.247-0.295) and an intercept of 2.688 for Otariidae of several different species. It is important to note that Silva (1998) only sampled adults.

DISCUSSION

The Von Bertalanffy growth curve provided a better fit than the Gompertz growth curve for predicting sea lion length-at-age and weight-at-age data. Based on the fitted Von Bertalanffy growth curve sea lion females reach 90% of their asymptotic length by age 4 whereas males do not reach it until age 11. These values are consistent with important ages for the life history of sea lions; females become reproductive at age 4, and the average age of males holding territory is age 12. It is likely that animals of both sexes need to attain a minimum size to manage pregnancy or hold territory.

The relationship between length and age was similar to what Greig et al. (2005) reported for a smaller sample of stranded animals, even after correcting for an error in the data (they reported a maximum length for females of 217 cm because of an error in the recorded sex; the maximum length for females was actually 199 cm).

Prediction of age from length can be useful to assign an age to fisheries entangled sea lions where only a sex and length is recorded. However there was a considerable amount of variability in the length-at-age relationship, and we found that we could not predict exact age, but had good predictive ability if we classified animals into the following age categories: pups (< 1 year old), 1-2 years old, and ≥3 years based on their lengths. This will help in apportioning mortality in fisheries data near the Channel Islands which entangle primarily younger sea lions. Because sea lion males do not reach 90% of their asymptotic length until age 11 (versus females that reach it by age 4), the use of four age categories (< 1 year old, 1-2 years old, ≥ 2-7 years old and > 8 years old may be useful.

The weight-at-age relationship was much more variable than the length-at-age relationship due to smaller sample size and the vagaries of seasonal and annual weight loss and gain; however, it had good predictive ability for the younger ages (3.5-8 months). In addition, comparison of predictions from a linear model with those from the Von Bertalanffy growth model suggested that the simpler linear model was adequate for animals of ages 3.5 to 8 months.

The exponent of the power law for weight-length allometry in sea lions was 2.8 for both sexes. Clearly, the exponent will depend on body shape. For a fixed value of a, animals with a larger circumference relative to length will have a larger exponent. In humans, the body mass index is based on weight being approximately proportional to the square of height ($b = 2$); although MacKay (2010) has argued that it should be closer to 2.66, at least for human children (based on biomechanical and heat loss). Our results were consistent with those of Silva (1998) for Otariidae of several different species.

ACKNOWLEDGMENTS

We appreciate the contribution of the staff and volunteers at The Marine Mammal Center and for Mark Lowry, Southwest Fisheries Science Center, who helped collect data at San Clemente Island. We are thankful to all of the people who have assisted with the marking programs at San Nicolas Island and San Miguel Island from which most of the pup data were derived. We also thank everyone who assisted with sea lion research conducted at the Año Nuevo Island UC Natural Reserve with the approval of Año Nuevo State Park for the use of their juvenile sea lion length data. We thank Harriet Huber and Rod Towell for review comments which improved this manuscript. This work was in part supported by John H. Prescott Marine Mammal Rescue Assistance Grant Program and the National Science Foundation (OCE-1335657).

CITATIONS

Burnham, K.P., and D.R. Anderson. 2002. Model Selection and Multimodel Inference. Springer, New York.

Carretta, J. V., E. Oleson, D. W. Weller, A. R. Lang, K. A. Forney, J. Baker, B. Hanson, K. Martien, M. M. Muto, M. S. Lowry, J. Barlow, D. Lynch, L. Carswell, R. L. Brownell, D. K. Mattila, and M. C. Hill. 2013. U. S. Pacific Marine Mammal Stock Assessments: 2012. NOAA Tech Memo. NMFS-SWFSC-504. 378p.

Childerhouse, S., G. Dickie, and G. Hessel. 2004. Ageing live New Zealand sea lions (*Phocarctos hookeri*) using the first post-canine tooth. Wildlife Res. 31: 177-181.

Froese, R. 2006. Cube law, condition factor and weight–length relationships: history, meta-analysis and recommendations. J. Appl. Icthyol. 22:241-253.

Greig, D.J., F.M.D. Gulland, and C. Kreuder. 2005. A decade of live California sea lion (*Zalophus californianus*) strandings along the central California coast: Causes and trends, 1991-2000. Aquat. Mammals 31: 11-22.

Hobson, K.A., and J.L. Sease. 1998. Stable isotope analyses of tooth annuli reveal temporal dietary records: An example using Steller sea lions. Mar. Mammal Sci. 14: 116-129.

Legendre, P. 2014. lmodel2: Model II Regression. R package version 1.7-2. http://CRAN.R-project.org/package=lmodel2.

MacKay, N.J. 2010. Scaling of human body mass with height: The body mass index revisited. J. of Biomechanics 43(4): 764–6.

Ogle, D.H. 2015. FSA: Fisheries Stock Analysis. R package version 0.6.23.

R Core Team (2015). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Silva, M. 1998. Allometric scaling of body length: elastic or geometric similarity in mammalian design. J. Mammal. 79(1):20-32.

Table 1. -- Parameter estimates, standard errors (SE), and 95% confidence intervals (CI) for the Von Bertalanffy growth curves ($L = L_{inf}(1 - e^{-k(t-t_0)})$) for length ($L$ in cm) at age (t in yr) fitted to female and male California sea lion data. L_{inf} is the asymptotic length, K controls the growth rate and t_0 is defined to be the age at which length is 0.

Sex	Parameter	Estimate	SE	95% CI
Female	L_{inf}	163.64	1.02	161.74 , 165.74
	K	0.41	0.01	0.39 , 0.44
	t_0	-1.65	0.05	-1.76 , -1.56
Male	L_{inf}	231.55	5.80	221.39 , 243.61
	K	0.18	0.01	0.16 , 0.21
	t_0	-2.57	0.15	-2.90 , -2.29

Table 2. -- Predicted lengths and 95% bootstrap confidence intervals (CI) at various ages from fitted Von Bertalanffy growth curves for female and male sea lions. Age is the mid-point of the age interval, *n* is the sample size. Deviation is the percentage difference between predicted length at the mid-point and average length of sea lions in the age interval (100(predicted-observed)/predicted).

Sex	Age (yr)	n	Predicted length (cm)	95% CI	% Deviation
Female	0.125	686	85.3	85.0 , 85.7	5.3%
	0.375	6344	93.0	92.9 , 93.2	1.7%
	0.625	774	100.0	99.5 , 100.4	0.4%
	0.875	157	106.2	105.5 , 106.9	3.6%
	1.5	32	119.3	118.1 , 120.4	4.1%
	2.5	30	134.4	133 , 135.6	4.6%
	3.5	17	144.3	143 , 145.6	-0.7%
	5	26	153.2	152.2 , 154.6	1.5%
	7.5	71	160.0	158.7 , 161.8	-0.9%
	12	69	163.1	161.6 , 165.5	-0.6%
Male	0.125	802	90.4	89.9 , 90.8	6.1%
	0.375	4199	96.7	96.4 , 96.9	0.9%
	0.625	642	102.8	102.1 , 103.4	-1.2%
	0.875	136	108.5	107.5 , 109.7	3.6%
	1.5	28	121.9	119.9 , 124	3.9%
	4	39	162.3	158.8 , 165.6	6.0%
	7.5	22	195.1	191.7 , 198.4	-0.1%
	12	33	215.6	209.7 , 220.5	-1.7%

Table 3. -- Proportion of female and male sea lions of known age classified to an estimated age category based on their length.

Sex	Age (yr)	Length (cm)		
		<109	109-139	140+
Female	< 1	0.982	0.018	0.000
	1 and 2	0.059	0.882	0.059
	≥ 3	0.000	0.043	0.957
		<112	112-148	149+
Male	< 1	0.965	0.035	0.000
	1 and 2	0.125	0.750	0.125
	≥ 3	0.011	0.140	0.849

Table 4. -- Parameter estimates, standard errors (SE), and 95% confidence intervals (CI) for the Von Bertalanffy weight at age growth curves ($W = W_{inf}(1 - e^{-k(t-t_0)})$) for weight ($W$ in kg) at age (t in yr) fitted to female and male California sea lion data. W_{inf} is the asymptotic weight, K controls the growth rate and t_0 is defined to be the age at which length is 0.

Sex	Parameter	Estimate	SE	95% CI
Female	W_{inf}	115.48	10.90	89.13 , 131.49
	K	0.18	0.03	0.15 , 0.26
	t_0	-0.57	0.04	-0.64 , -0.47
Male	W_{inf}	597.86	7542.47	310.91 , 22683.31
	K	0.04	0.03	0.00 , 0.09
	t_0	-0.53	0.10	-0.75 , -0.38

Table 5. -- Predicted weights and 95% bootstrap confidence intervals (CI) at various ages from fitted Von Bertalanffy growth curves for female and male sea lions. Age is the mid-point of the age interval, *n* is the sample size. Deviation is the percentage difference between predicted weight at the mid-point and average weight of seals in the age interval (100(predicted-observed)/predicted).

Sex	Age (yr)	n	Predicted weight (kg)	95% CI	% Deviation
Female	0.125	834	13.7	13.4 , 14	10.0%
	0.375	8674	18.2	18.1 , 18.4	6.1%
	0.625	860	22.6	22.2 , 23	-3.2%
	0.875	150	26.7	26.1 , 27.4	5.0%
	1.5	23	36.2	35.2 , 37.3	6.6%
	2.5	20	49.4	47.8 , 50.9	13.7%
	3.5	12	60.4	57.9 , 62.3	13.3%
	5	3	73.6	68.3 , 76.3	10.2%
	7.5	5	88.9	78.4 , 93.2	-0.9%
	12	5	103.8	85.1 , 111.8	-5.6%
Male	0.125	931	15.3	14.3 , 16	6.5%
	0.375	6260	21.0	20.2 , 21.3	6.0%
	0.625	738	26.6	24.8 , 28	-0.6%
	0.875	136	32.2	29.3 , 34.7	16.9%
	1.5	11	45.9	40.5 , 50.7	32.6%
	4	2	97.6	85.4 , 108.2	32.4%
	7.5	7	161.9	144.9 , 176.8	-21.8%
	12	14	232.6	201.2 , 259.1	7.4%

Table 6. -- Parameter estimates, standard errors (SE), and 95% confidence intervals (CI) for the weight (*W*) and length (*L*) non-linear regression $W = aL^b$ where *a* is the slope and *b* is the power law exponent.

Sex	Parameter	Estimate	SE	95% CI
Female	a	5.462e-05	1.248e-05	3.526e-05 , 8.515e-05
	b	2.802	0.049	2.704 , 2.894
Male	a	6.160e-05	3.503e-05	2.710e-05 , 1.618e-04
	b	2.778	0.098	2.566 , 2.956

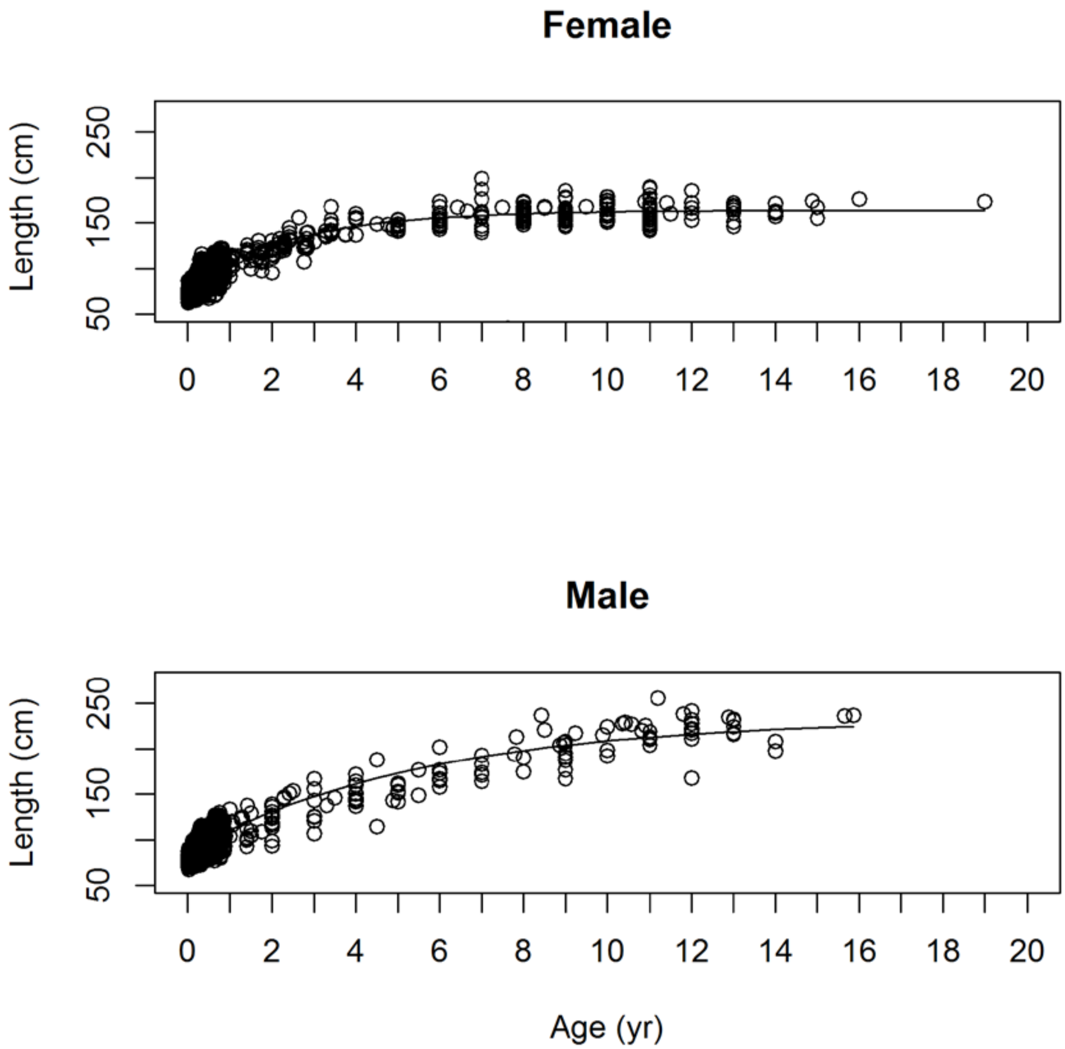

Figure 1. -- Von Bertalanffy growth curve fitted to age-length data for female and male sea lions. Parameter estimates are given in Table 1.

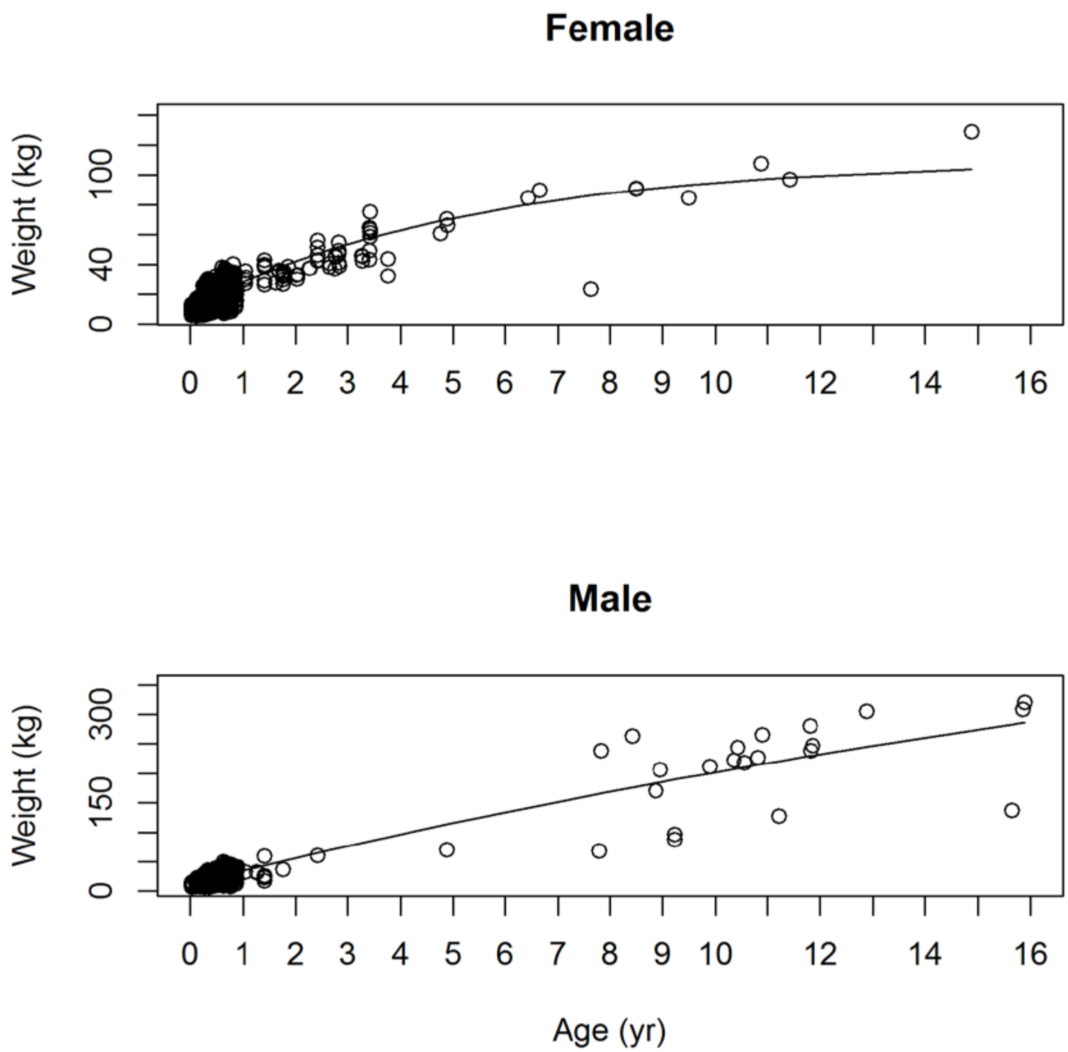

Figure 2. -- Von Bertalanffy growth curve fitted to age-weight data for female and male sea lions. Parameter estimates given in Table 3.

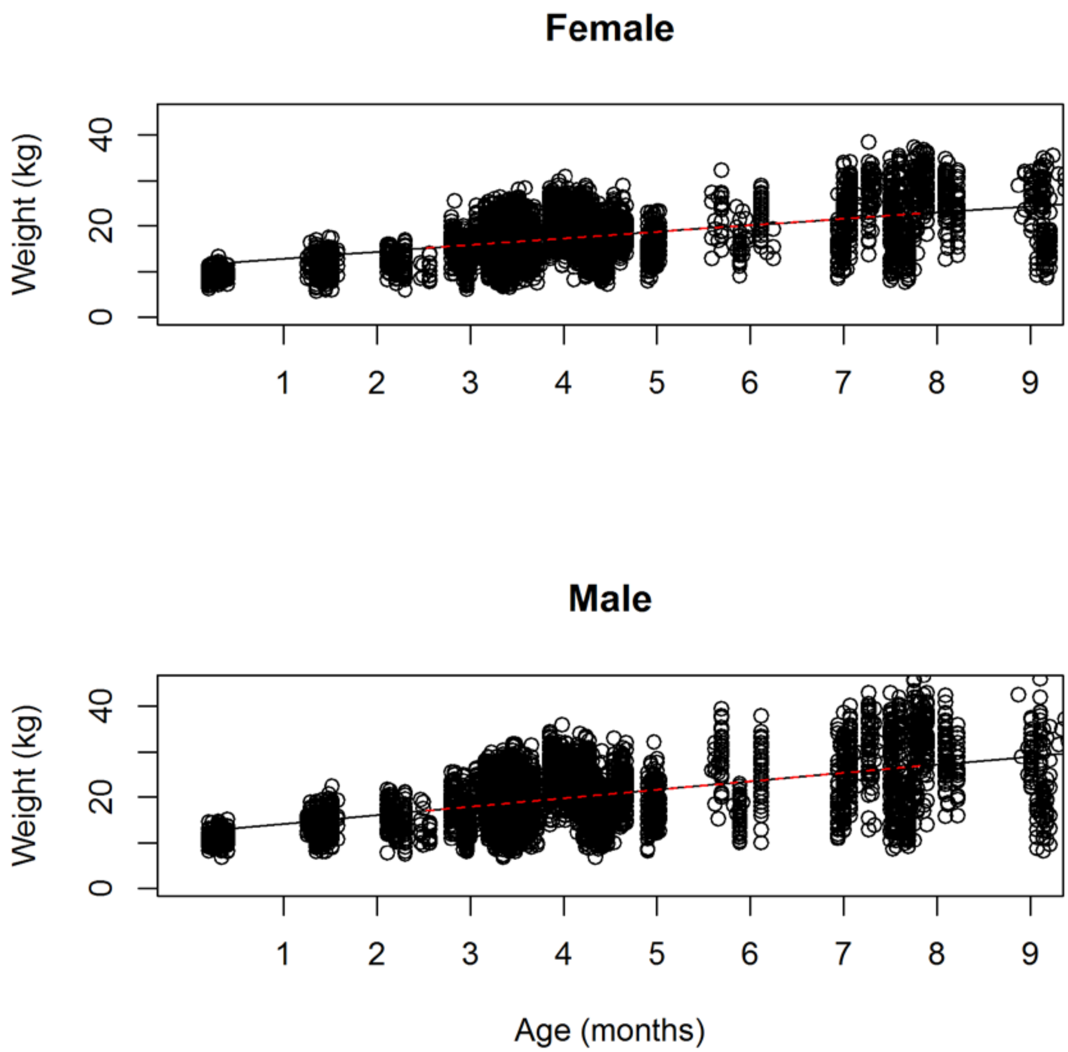

Figure 3. -- Von Bertalanffy growth curve fitted to all age-weight data (solid line) and linear fit shown for age 3.5-8 months (dashed line) for California sea lions.

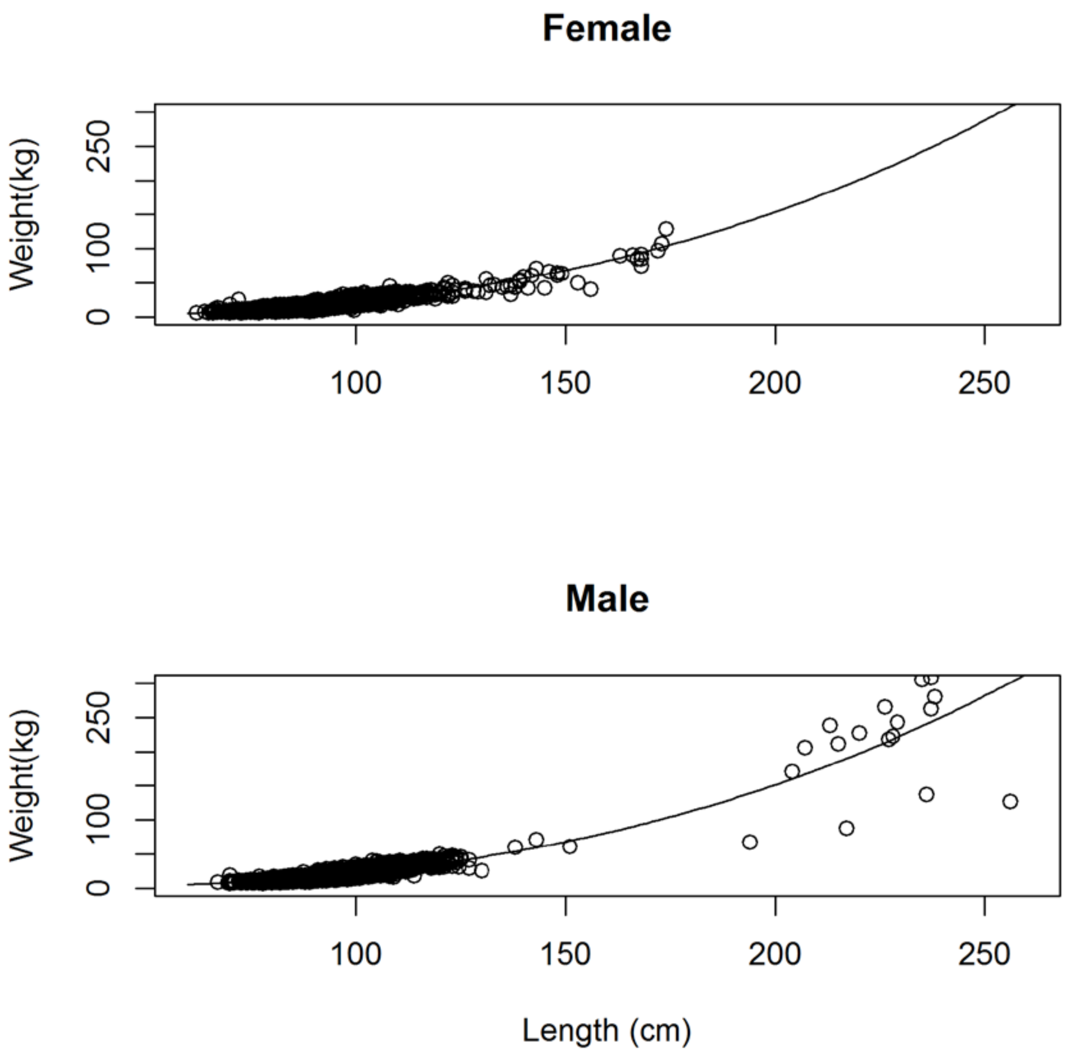

Figure 4. -- Nonlinear regression of weight at length for female and male sea lions.

RECENT TECHNICAL MEMORANDUMS

Copies of this and other NOAA Technical Memorandums are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22167 (web site: *www.ntis.gov)*. Paper and electronic (.pdf) copies vary in price.

AFSC-

311 GUTHRIE, C. M. III, HV. T. NGUYEN, and J. R. GUYON. 2016. Genetic stock composition analysis of the Chinook salmon bycatch samples from the 2014 Gulf of Alaska trawl fisheries, 31 p. NTIS No. PB2016-101398.

310 GUTHRIE, C. M. III, HV. T. NGUYEN, and J. R. GUYON. 2016. Genetic stock composition analysis of the Chinook salmon bycatch from the 2014 Bering Sea walleye pollock (Gadus chalcogrammus) trawl fishery, 25 p. NTIS No. PB2016-101397.

309 GUTHRIE, C. M. III, Hv. T. NGUYEN, and J. R. GUYON. 2016. Genetic stock composition analysis of the Chinook salmon bycatch from the 2014 Bering Sea walleye pollock (*Gadus chalcogrammus*) trawl fishery, 25 p. NTIS No. PB2016-101396.

308 DALY, B. J., C. E. ARMISTEAD, and R. J. FOY. 2015. The 2015 eastern Bering Sea continental shelf bottom trawl survey: Results for commercial crab, 167 p. NTIS No. PB2016-100681.

307 FAUNCE, C. H. 2015. An initial analysis of alternative sample designs for the deployment of observers in Alaska, 33 p. NTIS No. PB206-100705.

306 HIMES-CORNELL, A., S. KASPERSKI, K. KENT, C. MAGUIRE, M. DOWNS, S. WEIDLICH, and S. RUSSELL. 2015. Social baseline of the Gulf of Alaska groundfish trawl fishery: Results of the 2014 social survey, 98 p. plus Appendices. NTIS No.PB2016-100045.

305 FISSEL, B. E. 2015. Methods for the Alaska groundfish first-wholesale price projections: Section 6 of the Economic Status of the Groundfish Fisheries off Alaska, 39 p. NTIS No. PB2016-100044 .

304 HIMES-CORNELL, A., and K. KENT. 2015. Industry perceptions of measures to affect access to quota shares, active participation, and lease rates in the Bering Sea and Aleutian Islands crab fisheries. U.S. Dep. Commer., 67 p. NTIS No. PB2016-100043.

303 GRAY, A. K., C. J. RODGVELLER, and C. R. LUNSFORD. 2015. Evidence of multiple paternity in quillback rockfish (*Sebastes maliger*), 25 p. NTIS No. PB2016-100036.

302 FAUNCE, C., J. GASPER, J. CAHALAN, S. LOWE, R. WEBSTER, and T. A’MAR. 2015. Deployment performance review of the 2014 North Pacific Groundfish and Halibut Observer Program, 55 p. NTIS PB2015-105670.

301 ALLEN, B. M., and R. P. ANGLISS. 2015. Alaska marine mammal stock assessments, 2014, 304 p. NTIS No. PB2015-105669.

300 HELKER, V. T., B. M. ALLEN, and L. A. JEMISON. 2015. Human-caused injury and mortality of NMFS-managed Alaska marine mammal stocks, 2009-2013, 94 p. NTIS No. PB2015-105160.

299 LEW, D. K., G. SAMPSON, A. HIMES-CORNELL, J. LEE, and B. GARBER-YONTS. 2015. Costs, earnings, and employment in the Alaska saltwater sport fishing charter sector, 2011-2013, 134 p. NTIS No. PB2015-104937.

298 PRESCOTT, M. M., and M. ZIMMERMANN. 2015. Smooth sheet bathymetry of Norton Sound, 23 p. NTIS No. PB2015-104936.

297 VON SZALAY, P. G. 2015. The impact of sample size reduction on the precision of biomass estimates in the Gulf of Alaska, 17 p. NTIS No. PB2016-100042.

296 STONE, R. L., D. STEVENSON, and S. BROOKE. 2015. Assessment of a pilot study to collect coral bycatch data from the Alaska commercial fishing fleet, 45 p. NTIS No. PB2015-104935.