Indices of Condition in Steller Sea Lions (*Eumetopias jubatus*)

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Several studies have utilized traditional indices of body morphology to describe the condition of Steller sea lions throughout their range. Two studies have shown that pups less than 5 weeks of age in the western portion of their range (area of decline) have higher body mass than those in the area of stable population (Merrick et al. 1995, Rea et al. 1998). Similarly adult females in the western population have been found to be "rounder, longer and heavier than their Southeast Alaska counterparts with lower percent body water, reflecting higher body fat content" (M. Castellini, Univ. of Alaska Fairbanks, Feb. 1999, pers. comm.). Although standard morphometric indices such as standard length and axillary girth have been shown to be predictive of total body mass (Castellini and Calkins 1993), these parameters have been shown to be poor indicators of blubber thickness in Steller sea lion pups (Trites and Jonker 2000). Condition and density indices were unable to distinguish between starveling and average pups (Rea 1995) and LMD-index (using standard length, mass, and dorsal blubber depth measures) explained only 58% of the variability in sculp mass in animals collected between 1975 and 1989 ($n = 523$; Pitcher et al. 2000). Density index, calculated as $[\text{mass}/(SL \times AG^2)] \times 10^6$, was not significantly correlated with total percent body fat measured by deuterium dilution technique in 140 juvenile animals aged 2 months to 5 years ($r^2 = 0.01$, Fig. 1).

Percent body fat content has been shown to significantly decrease during food limitation in 7 to 14 day captive fasting studies (0.8 ± 0.4 % decrease in lipid per day as a percent of original body mass, $n = 16$). Thus the estimation of total body water (TBW) and the subsequent calculation of total body fat is currently considered the best index of body condition. This technique requires a minimum animal handling time of 2 hours for equilibration of the injected labeled water; thus it has often proven to be the limiting factor in the number of free-ranging animals studied during

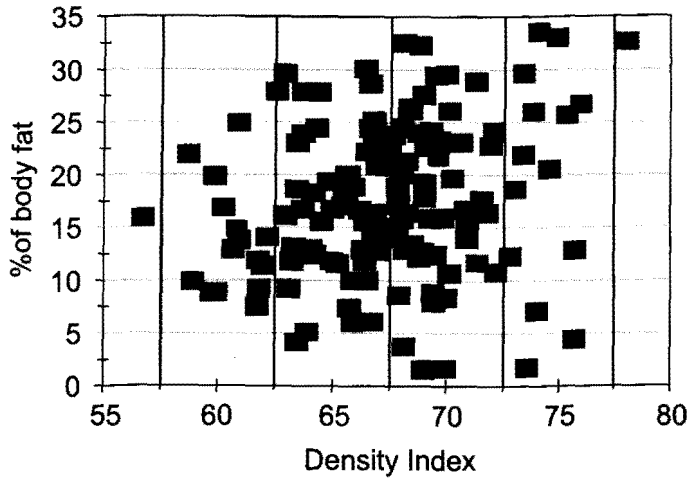

Figure 1. Density index, calculated as [mass/(SL × AG²)] × 10⁶, versus percent body fat content (as determined by deuterium dilution) for Steller sea lions between 2 months and 5 years of age ($r^2 = 0.01$, $n = 140$).

field investigations. Research has been under way to validate the use of bioelectrical impedance analysis (BIA) as an index of body condition in Steller sea lions as it is an instantaneous measure of TBW. Preliminary data show that TBW determined by BIA is highly correlated with TBW as estimated by the longer deuterium dilution technique (actual TBW = 0.985* [predicted]; forced through zero; $r^2 = 0.89$; $P < 0.0001$; Castellini 2001). This regression is particularly strong for small body sizes (up to 150 kg), although there is increased noise in this relationship in animals above 150 kg.

Percent body fat data (estimated by deuterium dilution) is currently available for 119 sea lions, ranging from 2 to 26 months of age (southeast Alaska $n = 74$; Prince William Sound $n = 45$). An additional 50 samples are under analysis (Kodiak Island area $n = 13$; southeast Alaska $n = 37$). Given our attempt to distribute sampling coverage throughout the year to investigate several aspects of development of juvenile Steller sea lions, sample sizes at any particular age are not yet sufficiently large to make reliable regional or gender based comparisons. Body fat content within each age group sampled is highly variable, particularly after 10 months of age. I would caution that percent body fat alone, without consideration of the weaning status of that particular sea lion, could be a misleading indicator of fitness. Phocid seals have been documented to decrease body fat content by 15% over a 2 week captive period of feeding on fish following a sustained post-weaning fast by significantly increasing lean body mass growth relative to adipose tissue growth (Rea 1990).

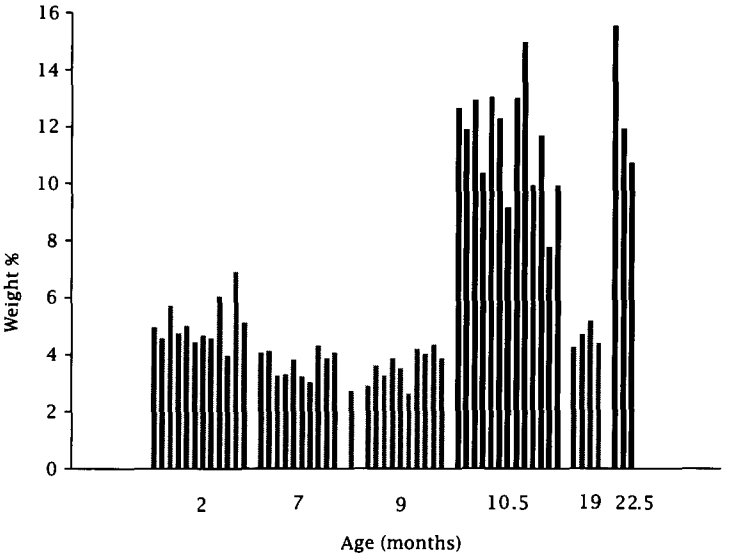

Figure 2. Weight percent of 20:1-11 fatty acid in blubber lipids of Steller sea lion juveniles 2-26 months of age, captured in southeast Alaska (gray bars) and Prince William Sound (black bars).

Preliminary data on fatty acid signatures show close correspondence between the lipid profiles of milk collected from the stomach of one 7-month-old sea lion and blubber collected from that animal ($n = 1$) suggesting that blubber profiles will prove to be a representative composite of diet in Steller sea lions. Two fatty acids which are indicative of prey are not readily transferred into milk in phocids (20:1w-11 and 22:1w-11 fatty acids, Fig. 2). Relatively high levels of these "prey" fatty acids were seen in 10.5- ($n = 12$) and 22.5- ($n = 3$) month-old sea lions captured in Prince William Sound. This could indicate either that Prince William Sound animals are relying more heavily on fish than 9- or 19-month-old sea lions in southeast Alaska, or that milk ingested by the Prince William Sound animals had a higher content of these fatty acids. Additional milk and collected blubber biopsy samples are currently being analyzed from both areas. If Prince William Sound milk samples prove similar in composition to that from southeast Alaska, these two fatty acids may provide evidence to identify juveniles that are at least supplementing their diet with fish. It will be important to look at individual patterns of fatty acid distribution, along with body composition, to be able to achieve our goal of identifying sea lions that are nutritionally independent.

Nutritional blood chemistry parameters such as ketone body (B-hydroxybutyrate or B-HBA) and blood urea nitrogen (BUN) concentrations have been shown to change significantly in response to food limitation in fasting studies on 6 week old pups (Rea et al. 2000). Similar changes in B-HBA have not been demonstrated by fasting juvenile sea lions over the age of 1.5 years. Thus, B-HBA has proven to be a useful tool in determining the proportion of handled pups at a site that are currently fasting. Published blood chemistry data have demonstrated that a higher proportion of pups studied in the 1990s in southeast Alaska showed B-HBA levels indicative of fasting than those pups sampled in the area of decline (Rea et al. 1998). These data are supported by observations of longer at-sea foraging times in southeast Alaska during the time of the study; thus pups were left alone fasting on the rookery for longer periods. Similarly, significantly higher B-HBA levels were measured in sea lion pups captured on Ugamak Island in 1997 (compared to 4 previous years of capture) coinciding with anomalous warm oceanographic conditions and low relative acoustic biomass signals at that location.

Plasma levels of the hormone leptin have been shown to be related to body and metabolic condition in several mammal species. Preliminary data on Steller sea lions have shown leptin concentrations to change during periods of food limitation with levels increasing in juvenile female sea lions ($n = 2$) during captive fasting experiments, and decreasing in similar fasting studies on male sea lions ($n = 3$). Plasma leptin levels were not highly correlated with total body fat content; however, ongoing research in this area will further consider the role of other factors now recognized to influence leptin secretion in other mammals, such as nutritional state (fasting/feeding), season, reproductive hormone levels, and circadian rhythm in this relationship. There is promise that when leptin is measured in concert with other hormonal indicators (e.g. thyroid hormones), an informative profile of metabolic condition can be developed.

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STELLER SEA LION DECLINE: IS IT FOOD II

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