Examining the ontogeny of foraging behaviors of the California sea lion (Zalophus californianus) using stable isotope analysis

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BACKGROUND

The California sea lion is a marine mammal that leads an amphibious existence. During their ontogeny they undergo physical, behavioral, morphological, and physiological changes as they go through a purely terrestrial phase after birth relying on their mother’s milk and with age they gradually forage independently in the aquatic environment. Recently, stable isotope analysis (SIA) was developed to augment conventional techniques (e.g. observations, scat analysis) in assessing the foraging ecology of marine mammals. SIA is based on the fact that isotopic ratios in animal tissues are related to those of their prey.

The enrichment of δ15N results from the preferential excretion of 14N usually in the form of urea or ammonia. Retention of δ15N varies according diet and nutritional stress, however a stepwise trophic enrichment has been found in several studies. Because of this enrichment, it theoretically would be possible to examine the weaning process because the suckling offspring would be consuming its mother’s tissue (i.e. milk) when young but its isotopic signature would decrease approach that of its mother as it begins to obtain nourishment from items of the adult-type diet.

Carbon-isotope ratios in the marine environment are directly affected by factors that act at the level of primary production resulting in geographic differences in δ13C/δ15N ratios that can be used to trace the energy flow from the base of marine systems and indicate consumer forage location.

Isotope ratios in a predator’s tissues are derived from assimilated food over a period of time, and the duration of that period depends on the metabolic activity of the tissue being analyzed. Therefore, isotope measurement of multiple tissues from the same individual can provide dietary information on various temporal scales.

METHODS

Tissues (i.e. fur, cellular blood, plasma, and/or serum) were collected from California sea lions of various age and sex classes at San Miguel Island, California during 2004 through 2007. Additionally, fur was collected from adult male sea lions at Shackle Island, California. The National Marine Mammal Laboratory (NMML) is located on Shackle Island.

Carbon (δ13C) and nitrogen (δ15N) isotope values of tissues were determined using a mass spectrometer at the Carnegie Institution of Washington.

Generalized additive models (GAMs) were used to examine differences in isotope ratios among tissues within known-aged individuals. Analysis of variance (ANOVA) was used to quantify isotopic discrimination among tissues with different age classes.

RESULTS/CONCLUSIONS

• Pups were δ15N-enriched (~1.5‰) and δ13C-depleted (~0.5‰) corresponding to feeding at a higher trophic level (i.e. their mother’s tissues) and on a lipid-rich diet (milk, which is δ13C-depleted relative to proteins).

• There were significant differences in δ15N and δ13C among age classes; as individuals mature, their stable isotope signatures approach those of adults; there were no significant differences between sexes.

• There were significant differences in δ15N and δ13C among tissues except between plasma and serum. These two tissues were slightly δ15N-enriched and δ13C-depleted compared to fur and cellular blood, both of which have slower growth and turnover rates, respectively.

• Pups of GAM illustrated that there were significant decreases in δ15N (for blood components) at approximately 8 or 9 months of age indicating the onset of weaning. Patterns of fur for pre-20-month olds were suspect and may be attributed to various factors (e.g. sample size, timing of collection, etc.)

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