Elemental Ecology
SIMMR Mixing Model Exercise
Due at <u>Beginning of Class</u> on Thursday November 4th

Problem #1: Sea Lion SIMMR!

My close colleague Dra. Maritza Sepulveda (University of Valparaiso) studies sea lions along the southern coast of Chile just south of Puerto Montt. This area is home to one of the most productive salmon aquaculture regions in the world. Salmon are raised in floating pens in coastal bays and fjords, but are fed a specially formulated fishmeal that calorically is dominated by soy, a C_3 plant. Maritza and her colleagues are trying to figure out how often sea lions consume farmed salmon by exploiting the gradient in isotopic composition between the sea lions natural fish prey and that of the (hippy dippy) farmed salmon largely raised on tofu. To do so, Maritza collects samples of potential natural prey items and farmed salmon obtained directly from pens; these data are listed in the worksheet entitled "Sea Lions" in the Excel spreadsheet that accompanies this exercise. In addition, Maritza and her students use crossbows to collect two types of tissue (hair and skin) from each of 15 individuals at a sea lion haul-out that is in close proximity to an area that contains a high density of salmon farms. She conducts her fieldwork at the end of the austral winter when it is believed that sea lions consume more farmed salmon than during the productive spring/summer months.

1) Use these data to construct a mixing model in SIMMR for the two types of tissues collected from each sea lion. Given the observed amount of variation in isotope values among individual sea lions, its best to quantify the diet for each individual rather than using mean values for each tissue type. You will have to search the literature for $\delta^{13}C$ and $\delta^{15}N$ trophic discrimination factors (TDFs) and decide whether you should be using the same or different TDFs for hair versus skin. Report your findings in a table showing the relative proportion of each prey type consumed by each individual.

2) What potential mechanisms (there are at least two) could explain the difference in isotope values and associated mixing model output for sea lion hair versus skin tissue? Hint: think about the time of the year represented by each tissue type and what each tissue is composed of when formulating your answer.

3) During the second year of the study, abnormal conditions led to an increase in the occurrence of southern sardines (*Sprattus fueguensis*) in the coastal bays and fjords where the sea lions forage. Usually, sardines are an open ocean forage fish that are rarely observed inshore. Maritza opportunistically collected a sample of sardines and measured their isotopic composition; their mean ($\pm$SD) $\delta^{13}C$ and $\delta^{15}N$ values are -15.6 $\pm$ 0.4‰ and 15.3 $\pm$ 0.2‰, respectively. How does the inclusion of this novel prey source change your results concerning what sea lions consume in this region? More importantly, how does the inclusion of this prey item affect the use of stable isotopes as a tool to quantify sea lion diets given its distribution in $\delta^{13}C$ versus $\delta^{15}N$ space relative to the other prey?

Problem #2: Sevilleta Smammal SIMMR!

As you know, my lab group traps small mammals at the Sevilleta National Wildlife Refuge (SNWR) monthly from March to November. This work is inspired by a previous study by Blair Wolf (UNM Biology) and his previous students Alaina Pershall-Zimmerman and Robin Warne. Our present work is using a combination of stable isotope analysis and direct measurements of small mammal body condition to provide a mechanistic framework for understanding how consumer diets are influenced by climate-mediated seasonal shifts in resource availability. One of our primary approaches is quantifying the isotopic niche of each small mammal species over time and then measuring the degree of overlap among species, which provides a proxy for resource competition in response to shifts in the abundance of composition of potential resources (plants).

In the associated Excel spreadsheet are blood plasma $\delta^{13}C$ and $\delta^{15}N$ values for five species of small mammals captured during three consecutive (2005–2007) summer monsoon seasons (July–September) from a mixed shrubland (creosote) and grassland (grama) site on the SNWR.

1) What are the relative contributions of C_3 and C_4 resources to each of the five species in each monsoon season (2005, 2006, and 2007)? Construct SIMMR models using appropriate blood plasma $\delta^{13}C$ and $\delta^{15}N$ trophic discrimination factors (TDFs) found in the literature and the following source $\delta^{13}C$ and $\delta^{15}N$ data. Please summarize your results in a table and provide a short narrative on the interesting patterns you observed.

Source	**Mean $\delta^{13}C$**	**$\delta^{13}C$ SD**	**Mean $\delta^{15}N$**	**$\delta^{15}N$ SD**
C_3 Shrubs	-26.2	0.9	5.7	1.5
C_3 Annuals	-28.6	2.2	1.6	2.4
C_4 Grass	-14.8	0.9	1.0	1.4

2) Construct three boxplots showing the relative proportions of C_3 shrubs, C_3 annuals, and C_4 plants in the diet of *Dipodomys spectabilis* in 2005, 2006, and 2007.