Introduction to Sonography

So far we have shared with you details about our fieldwork in Antarctica and we have talked a little bit about some of the laboratory analyses. Fieldwork here is slowing down as we preparing to leave Antarctica on December 1st. Thus with this update, we want to educate you on ultrasound, which is a vital methodology used for a component of one of our projects down here, "The Thermal Characteristics of Weddell Seals". Before we discuss what an ultrasound is, how it works, and what types of data we are obtaining with it, I would like to provide you with a brief background on thermoregulation in seals so that you know how the ultrasound methodology supports this study. Next I will discuss how ultrasound works. Finally, I will leave you with some of the data that we have collected from the seals, including actual ultrasound images!

Comparisons of adult arctic and tropical terrestrial mammals have revealed that thermal adaptability is due to insulative properties, such that arctic mammals maintain constant body temperatures just like tropical mammals simply by maintaining a thick "coat", which can be either fur and/ or fat. A thick, low-conductive subcutaneous blubber layer provides insulation so that adult marine mammals are able to maintain constant temperatures even when faced with the coldest of temperatures, as in Polar Regions like Antarctica. Undoubtedly thermoregulation is most challenging for immature mammals because their diminutive body sizes result in high surface area to volume ratios that provide a greater propensity for heat loss that could be exacerbated by underdeveloped thermoregulatory capabilities. In fact, in most terrestrial mammals, fat accumulates in the body after birth and continues to increase with age. Likewise, the insulative layer of marine mammals increases after birth. To understand how insulation varies across age, we have been taking a series of ultrasound measurements on animals that are 4-5 weeks-old (pups), 1-2 years-old (juveniles), and sexually mature adults.

The technical term for ultrasound imaging is sonography. Ultrasound is a noninvasive (meaning it does not penetrate the skin or body openings) imaging technique that is painless and has no harmful effects. Ultrasound is a procedure that uses high-frequency sound waves to view internal organs and produce images of the body. As sound passes through the body it produces echoes, which can identify distance, size, and shapes of objects inside. During the ultrasound examination, a machine called a tranducer is used to view the target organ. The transducer is placed on the body and it transmits sound. When the emitted sound encounters a border between two tissues that conduct sound differently, some of the sound waves bounce back to the transducer, creating an echo. The transducer then sends the information that it collects to the scanner, which generates the ultrasound image. Ultrasound technology was first used medically in the 1950s.

We are using a portable ultrasound unit, the Sonosite 180 Plus. Luckily we have had great success using this device in the field. We were at first concerned that the extreme conditions here in Antarctica may make the Ultraound system inoperable. Yet this device has operated for up to half an hour in extreme temperatures of –23.3 to –1.9 ° C, with winds up to 25 mph!

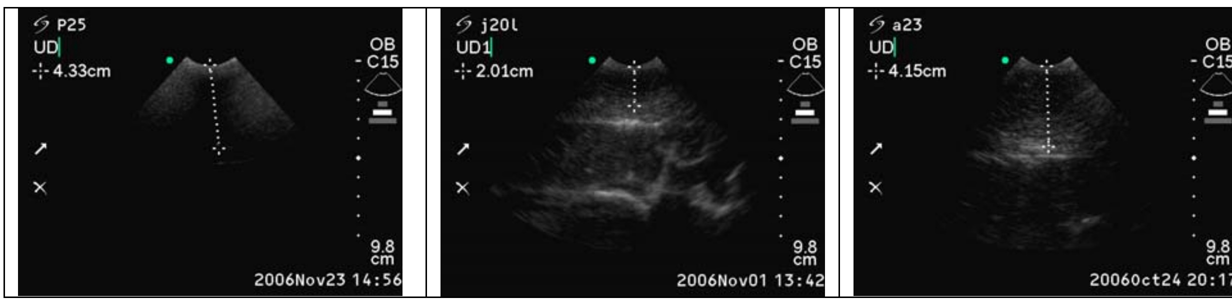
LINNEA AND SHAWN BEING PUSHED OVER BY EXTREME GUSTING WIND

Reading the screen in the sun (when we have sun) has sometimes been a problem, but we just use members of the team as “shades” to block the sun. The only real challenge has been to make sure that the fingers of the ultrasound operator do not develop frostbite and to try to get accurate readings from pups, which have not fully molted (newborn fur type is replaced by adult fur type). Pups are born with a pelage (lanugo) that is thicker and denser than that of adult fur. Fur insulates an animal by trapping pockets of air at the skin surface (similar to the way our ECW gear works), this provides an air boundary layer that increases the distance between the heat exchange areas (the animal’s skin and the environment). Thus the thicker, denser pup pelage traps more air than that of the adult pelage. This is important for providing adequate insulation for the pup as it develops its thick blubber layer. The pup does not undergo the molt until it has accumulated body fat. This natal pelage, however, had created a challenge for us because the ultrasound can not provide an image when it encounters air pockets. After some patience, combing of the fur, and lots of ultrasound gel the problem is often rectified. I simply provide this account to demonstrate to you that as a scientist you will encounter challenges in the field, but you must not give up. You must solve the problem in order to have a successful project.

NEWBORN PUP WITH LANUGO

PUPS STARTING TO MOLT

So onto the most exciting thing – let us look at the ultraound images and see what the data is telling us! Below is an example ultrasound from each age group that we analyzed. We measured 12 sites on each animal. Below is a representative animal from each age class (Pup 25, Juvenile 20, and Adult 23), showing the blubber measurement from the umbilicus dorsal region, which tended to have the thickest blubber across animals.



You will notice from this site for these particular animals that the pup (on the left) had the thickest blubber, followed by the adult (on the right), with the juvenile (in the middle) having the thinnest blubber. Yet body size increases from pup to juvenile to adult. Body size is undoubtedly related to the distribution of blubber in seals, 1) you may expect blubber thickness to decrease with age as the animal's surface area to volume ratio (propensity to loss body heat) decreases or 2) you may expect blubber thickness to increase with age to increase proportionately with the increase in body size. However, other factors must be considered to understand how blubber is distributed in a seal. First, blubber not only serves to insulate the animal, but it also serves as an energy reserve during periods of food stress. Thus, seals can utilize their blubber as fuel when prey is limited; this depletes the blubber thickness. Clearly, there is a balance because if the seal depletes too much blubber it will incur greater energetic costs associated with thermoregulation. Meanwhile, blubber is buoyant. Seals must locomote against this buoyant force when they dive to search for prey. Thus, there is an upper limit to the amount of blubber a seal of a particular body size can maintain before it incurs greater energetic costs associated with locomotion. These relationships lead me to the challenge question for this week.

Challenge Question

Why do you think that the seal pup had the thickest blubber while the juvenile pup had the thinnest blubber?