Apnea at Piedras Blancas

During the summer of 2016, Jenni Rind, a graduate student from Scotland did her Honors Thesis: The Effects of Age on Apnea and Eupnea in Subadult and Adult Male Northern Elephant Seals at the Piedras Blancas rookery. The following is a summary of her project.

In northern elephant seals (NES), terrestrial apnea is a natural and regularly occurring process which benefits the seals by increasing their ability to conserve vital fluids and energy stores while fasting on land[1]. NES have the longest known apnea (25 minutes) of a non-hibernating terrestrial mammal[1,2]. Furthermore it is believed that apnea, as part of the dive response at sea, and apnea ashore are related, and that by studying the seals on shore useful insights into the behavioral and physiological similarities of these apneas may be gained[3]. The aim of this study was to find whether the length of terrestrial apnea (not breathing) and eupnea (normal breathing) in male NES was affected by age and other variables such as time of day, temperature, cloud cover and contact with other seals.

102 *male NES* were placed in one of five categories from SAM 1 through SAM 4 and Adult based on their age, size, nose and chest shield development. Equal numbers of seals were chosen for each age category, and roughly equal numbers were studied within each of four time periods from 8am to 8pm. As with the Blackwell[1] study, seals were observed when they seemed to be sleeping, and data was recorded only if they remained sleeping for two consecutive bouts of apnea/eupnea. The length of each apnea and eupnea was recorded as was the length of each breath. Cloud cover, ambient temperature and whether the seal was in contact with other seals was also recorded. While, as we will see below, age was significantly related to the lengths of apneas and eupneas, neither the cloud cover, temperature or sleeping in contact with other seals had any measurable effect on the lengths of apneas or eupneas.

The youngest seals had the longest apneas (mean 9.7 min), and the oldest two groups the shortest (mean 6 min). The longest apnea was 19.8 min performed by a SAM 1. (Figure 1) One way to interpret the decrease in apnea seen with age is that as elephant seals develop and increase in size, the amount of oxygen storage per pound

also increases.[1,6] The older seals can retain needed water without spending as much time in apnea.[4]

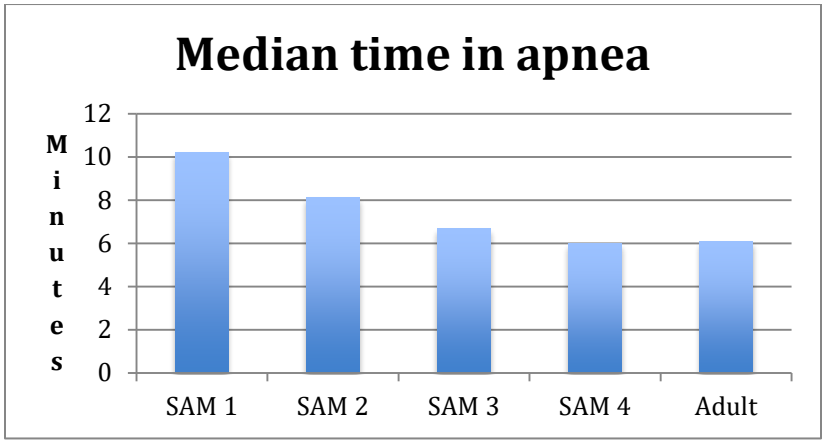

Figure 1

In contrast to the results displayed above for apnea, the average length of eupnea (normal breathing) showed an overall increase in older seals (4.5 min in SAM 1 to 6.5 min in Adults). (Figure 2) In addition, Adult males breathed at a lower rate in eupnea decreasing from Sam 1 (mean = 5.9 BPM (breaths per minute)) to Adult (mean = 4.4 BPM). Moreover, Adult males took more time for each breath (mean = 14.6 sec) compared to SAM 1 (mean = 11 sec). Not just the lengths of eupneas, but the percentage of the apnea/eupnea bout spent in eupnea increased with age.[5] Thus the older seals spent more of the bout breathing normally. Again, it is assumed that the efficiencies of size mean the older seals save as much water and energy as they need to even with longer eupneas and shorter apnea.

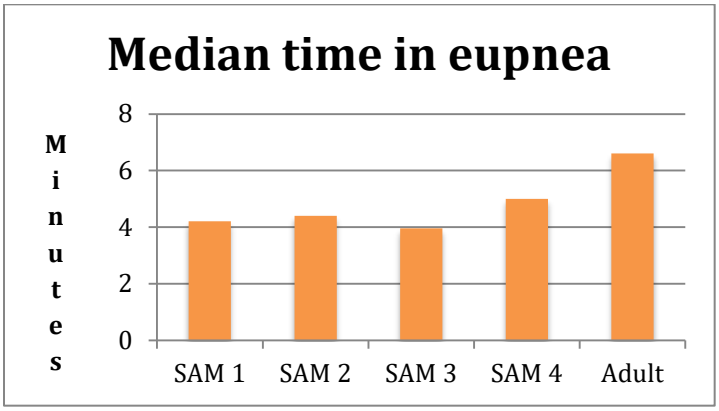

Figure 2.

These results agreed with the Blackwell[1] study which found that over all age groups, the oldest juveniles and SAM 1's had the longest apneas (mean 9.8 min) Blackwell's study took place during the birthing/breeding season, and it was interesting to find that the apnea lengths for adult males were about the same winter (Blackwell, mean 7.4 min) or summer (Rind, 6.3 min). These numbers are interesting because Blackwell and Le Boeuf suggested apneas of adult males would be longer if the males were not on the alert and competing, but just relaxing as during molting. Ms. Rind's results suggest we need to take a closer look as it appears that the level of aggression does not influence the length of apnea in relation to age.

[1]Blackwell, S. & Le Boeuf, B. (1993). *Developmental aspects of sleep apnoea in northern elephant seals, Mirounga angustirostris. J. Zool., Lond.*, **231:** 437-447.
[2]Bartholomew,G. (1954), *Body Temperature and Respiratory and Heart Rates in the Northern Elephant Seal.* Jour. Mamm., **2:** 211-218.
[3]Castellini, M., et al., (1994), *Patterns of respiration and heart rate during wakefulness And sleep in elephant seal pups. Am. J. Physiol. Regulatory Integrative Comp. Physiol*, **266:** 863-869.
[4]Ortiz, C. et al., (1978), *Water and Energy Flux in Elephant Seal Pups Fasting Under Natural Conditions. Physiol. Zool.*, **51:** 166-178.
[5]Murray, J. and Nadel, J. (2005), *Textbook of respiratory medicine. 6th ed.* Philadelphia, Pa: WB Saunders.
[6]Thorson, P. and Le Boeuf, B. (1994) *Developmental Aspects of Diving in Northern Elephant Seal Pups. Elephant Seals: Population Ecology, Behavior, and Physiology.* Springer.