

CARDIORESPIRATORY PATTERNS IN PINNIPEDS

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OBJECTIVE

Most knowledge concerning the dive response in pinnipeds comes from a few, well-studied species evaluated during submersion. Here, we consider typical breathing patterns and measures of heart rate for phocids, otariids, and an odobenid while resting out of water. Our aim is to discern reliable individual-, species-, or family-level differences in cardiorespiratory patterns, and consider how these differences relate to life history traits and phylogeny.

APPROACH

Electrocardiograms (ECGs) and respiratory behavior were recorded non-invasively from seven species of pinnipeds in human care. Individuals were conditioned to rest calmly out of water on an electroconductive surface. Instantaneous heart rate was determined from the interval between successive heart beats. Breaths were time-linked with ECGs.

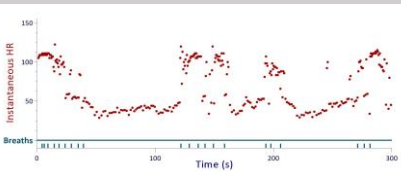
FINDINGS

Observations have suggested that some pinnipeds “dive” while at rest on land by punctuating extended breath holds with bouts of clustered respiratory events. Every subject in our study exhibited some degree of this intermittent breathing pattern, with bradycardia occurring during apnea and tachycardia occurring during eupnea. Similar cardiorespiratory patterns were evident within individuals and species, but there were notable differences between species and evolutionary groupings. Respiratory behavior varied from more regular to highly intermittent, driving predictable changes in heart rate. Both absolute values and dynamic ranges of cardiac responses were consistent within species.

Harbor Seal *Phoca vitulina*



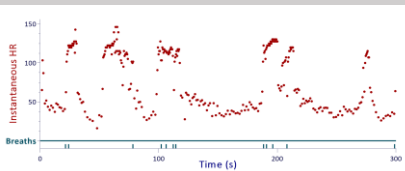
Intermittent breathing pattern
 Longer apnea duration > 45 s
 Clustered respirations: ~ 3 per minute
 Bradycardia : Tachycardia = 40 : 120 beats per minute



Spotted Seal *Phoca largha*



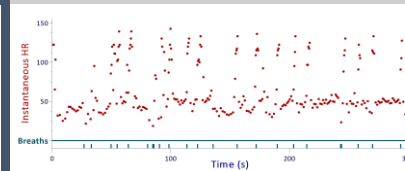
Intermittent breathing pattern
 Longer apnea duration > 45 s
 Clustered respirations: ~ 3 per minute
 Bradycardia : Tachycardia = 40 : 120 beats per minute



Ringed Seal *Pusa hispida*



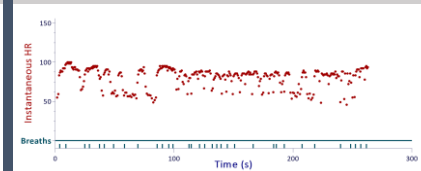
Intermittent breathing pattern
 Moderate apnea duration < 25 s
 Regular respirations: ~5 breaths per minute
 Bradycardia : Tachycardia = 50 : 120 beats per minute



Bearded Seal *Erignathus barbatus*



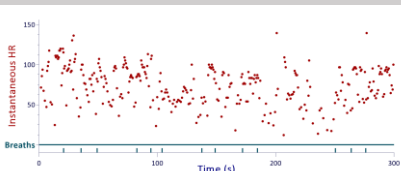
More regular breathing pattern
 Brief apnea duration < 10 s
 Average Respiratory Rate: ~ 8 breaths per minute
 Bradycardia : Tachycardia = 60 : 100 beats per minute



California Sea Lion *Zalophus californianus*



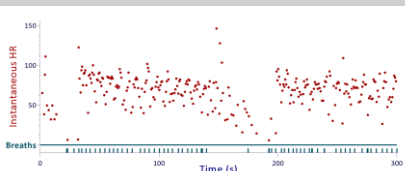
More regular breathing pattern
 Moderate apnea duration < 25 s
 Regular respirations: ~3 breaths per minute
 Bradycardia : Tachycardia = 40 : 120 beats per minute



Stellar Sea Lion *Eumetopias jubatus*



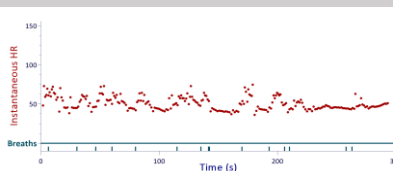
More regular breathing pattern
 Moderate apnea duration < 20 s
 Regular respirations: ~20 breaths per minute
 Bradycardia : Tachycardia = 40 : 100 beats per minute



Pacific Walrus *Odobenus rosmarus*



Punctuated breathing pattern
 Moderate apnea duration < 25 s
 Regular single respirations: ~3 breaths per minute
 Bradycardia : Tachycardia = 50 : 80 beats per minute



Next Steps

We plan to expand this dataset with additional subjects and species and conduct a quantitative, comparative analysis of key respiratory and cardiovascular parameters. This effort should reveal underlying physiological adaptations for amphibious living that fundamentally define the biology of pinniped carnivores.

