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Biomechanical energetics of terrestrial locomotion in California sea lions

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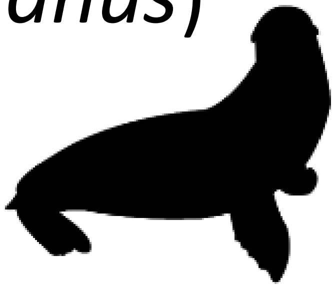
The Biomechanical Energetics of Terrestrial Locomotion in California Sea lions (*Zalophus californianus*)



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RCAD 2021

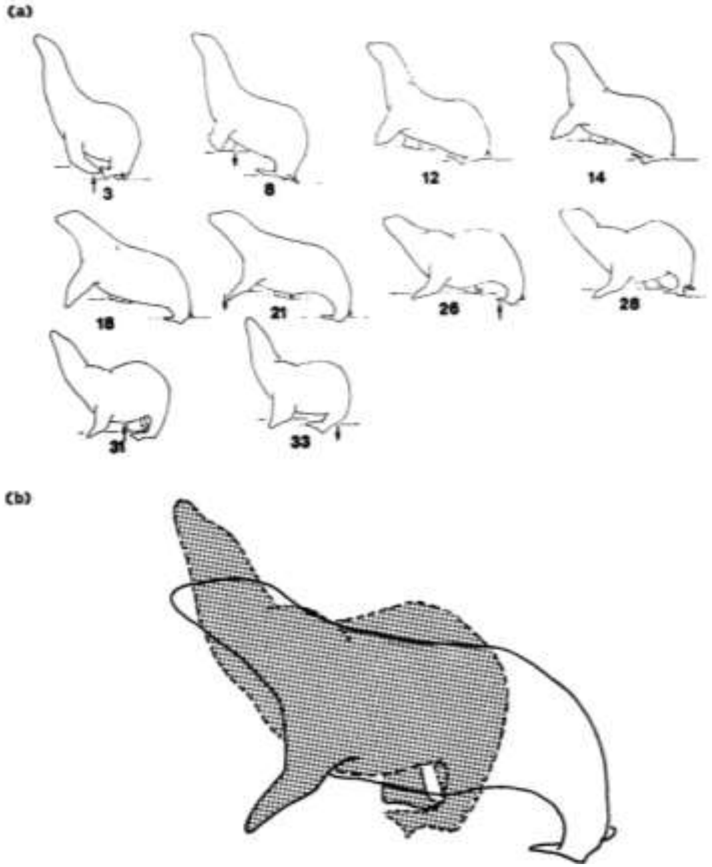
Zalophus californianus

- California sea lions spend a large portion of their year on land to reproduce.
  - Pups stay with their mother for up to a year

- Highly maneuverable in the water, propelling themselves primarily with forelimbs

- Locomote efficiently on land

Terrestrial Locomotion: The ability to "walk"



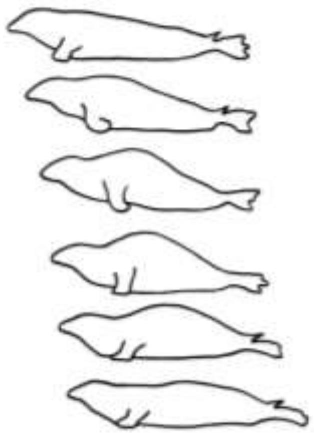
- California sea lions can pull their hindlimbs underneath them to walk and gallop.
- Elongated forelimbs aid in terrestrial and aquatic locomotion
- Limbs entirely support the weight of the body
- Flex their axial skeleton during forward locomotion

Terrestrial Locomotion: The ability to “walk”

- Phocids cannot pull their hindlimbs beneath their body, and they do not have the elongated forelimbs to aid in terrestrial locomotion.

- Limbs do not support their weight and they rely on a forward lunge.

- During forward movement, phocids’ trunks flex caudally to the chest, bringing the pelvis forward, thus pushing the anterior of the body forwards

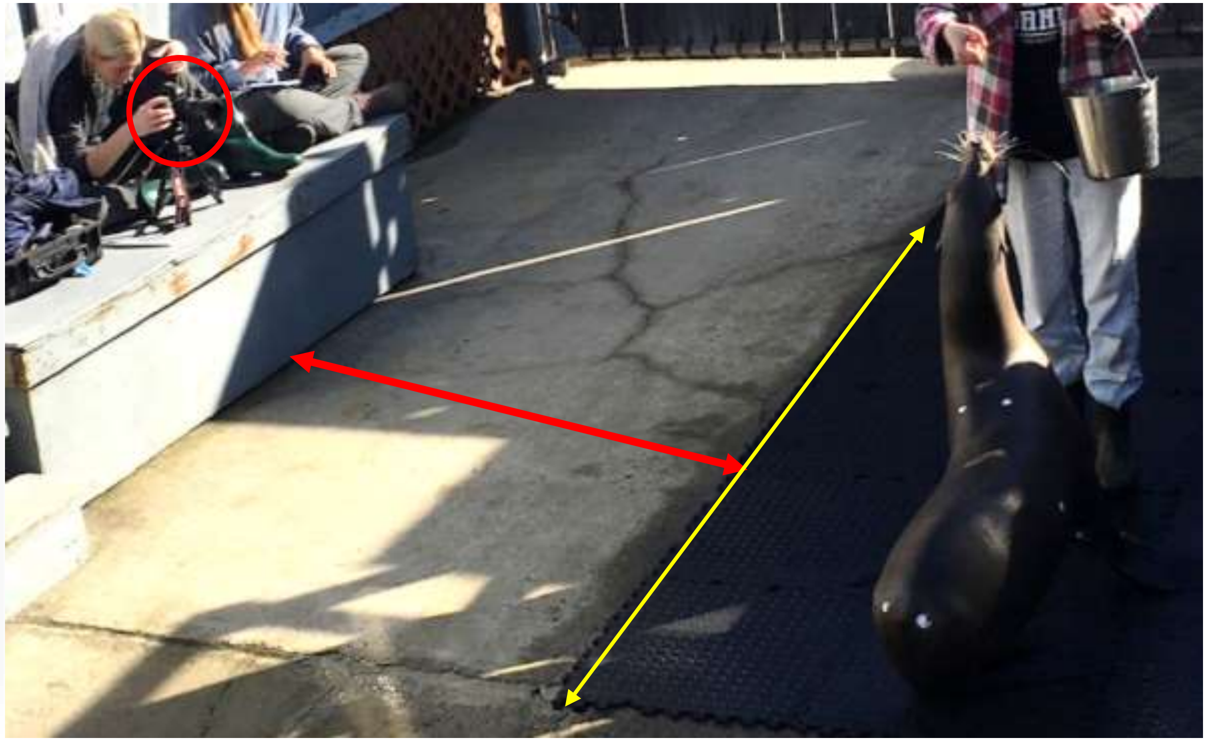


The Sea lions

S.L.E.W.T.H.S.

Science Learning and Exploration With The Help of Sea lions

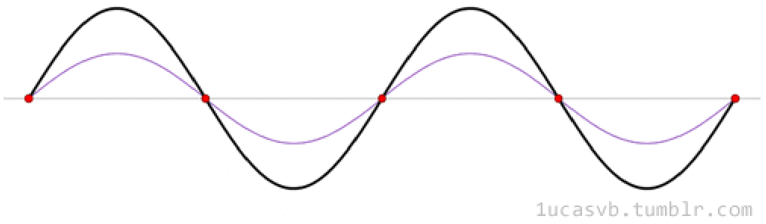
Ariel Nemo Cali



Energetics

Hypothesis: The quadrupedal gait of the California sea lion will be more efficient, showing a lower mechanical Cost of transport, when compared to the undulatory gait of the three phocid seals.

Energetics Equations



Variables input into the model included *x* (horizontal displacement) and *y* (vertical displacement) of marked body points, BL (body length), M (mass), absolute and transverse V (velocity), f (stride frequency), and A (vertical amplitude of their oscillations).

The average power, (P), which is the average rate at which both kinetic and potential energies are used by the animal, is then:

$$P = 2\left(\frac{dK}{dt}\right) = \frac{1}{2}\mu V \omega^2 A^2 = 2\pi^2 \mu V f^2 A^2$$

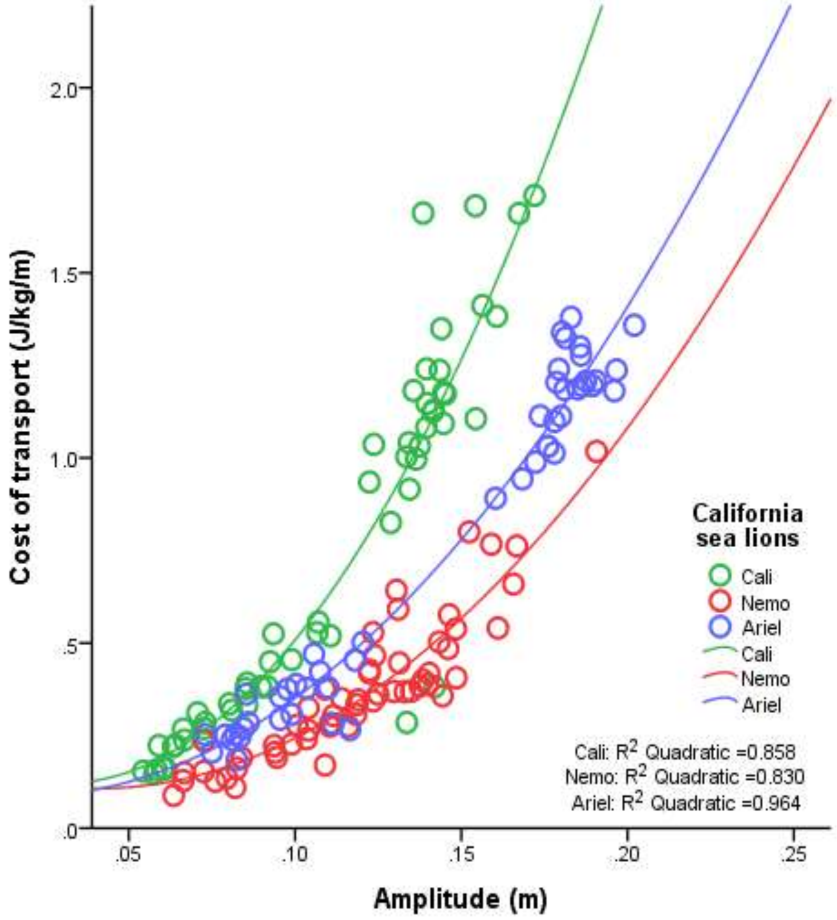
This model assumes that the animal is moving over flat ground. Cost of transport (COT) was determined by dividing the mass (M) and velocity (V) of the animals by their power output (P) in the following equation:

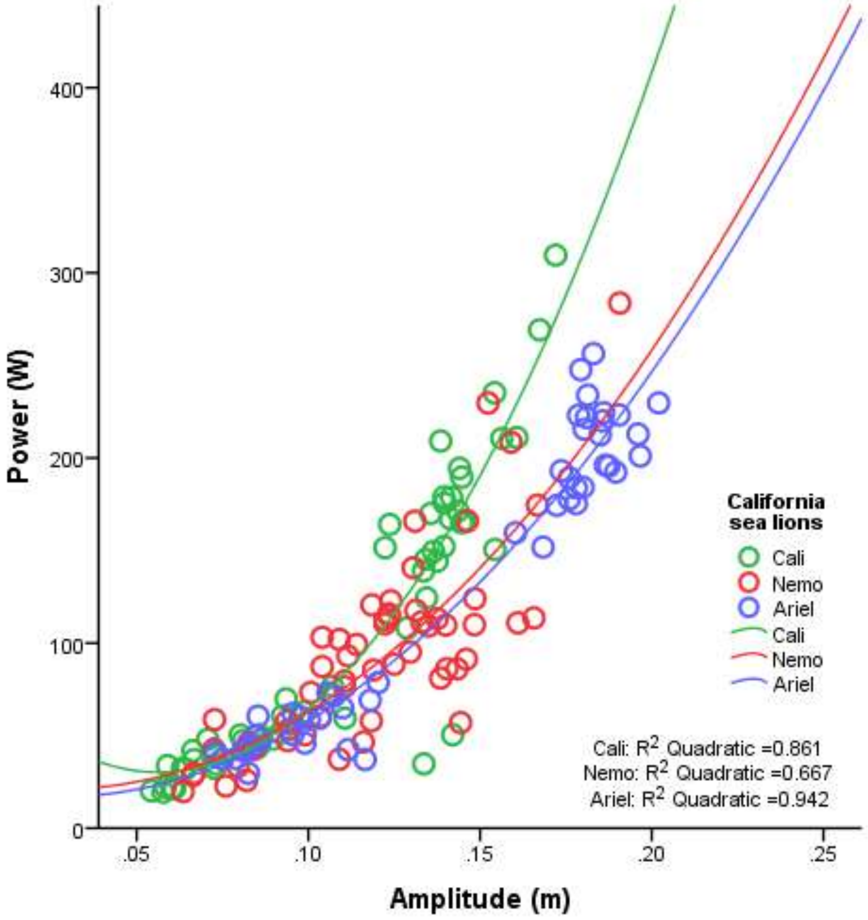
$$COT = P/M/V$$

Average Power output between the three sea lions was 112 watts

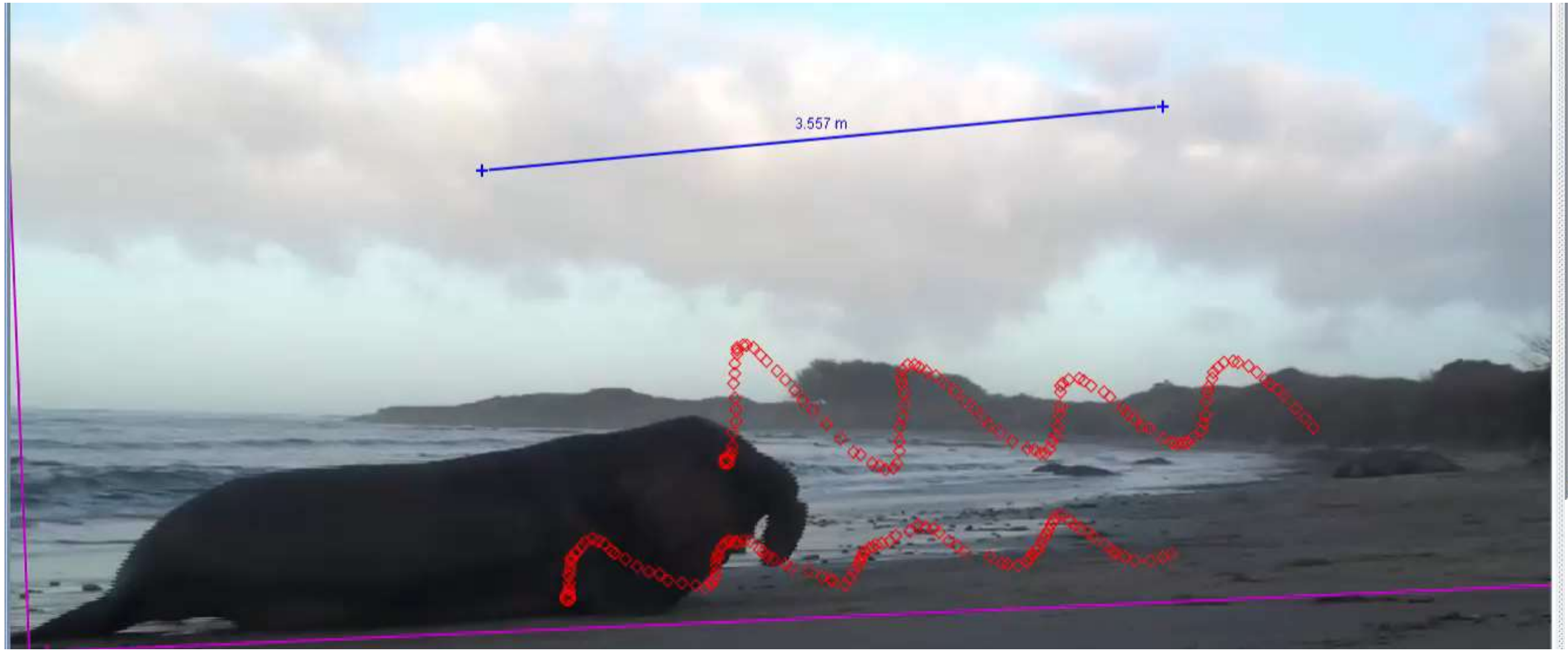
	Power	Cost of transport	Amplitude	Velocity
	W	*J/kg/m*	*m*	*m/s*
Cali	111.42±73.48	0.76±0.48	0.11±0.04	1.95±0.18
Nemo	93.41±51.73	0.37±0.19	0.12±0.029	1.78±0.32
Ariel	131.28±79.26	0.76±0.44	0.14±0.05	2.01±0.15
Mean	112.04±18.94	0.63±0.23	0.12±0.02	1.92±0.12

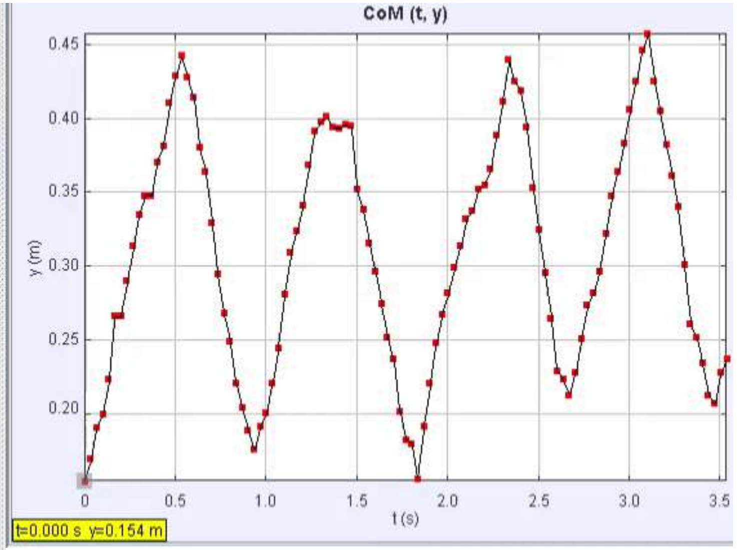
Positive correlation between COT and power output



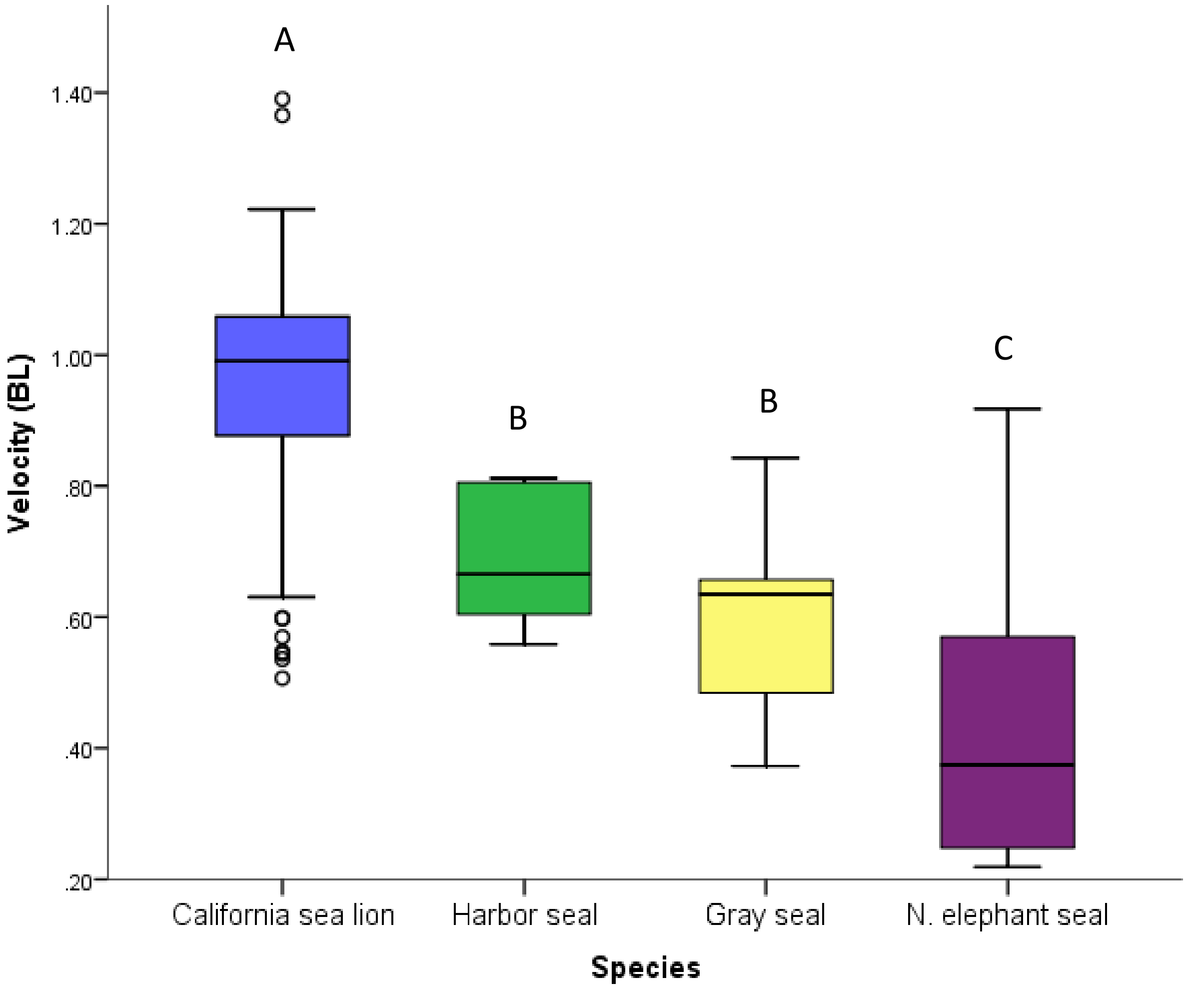


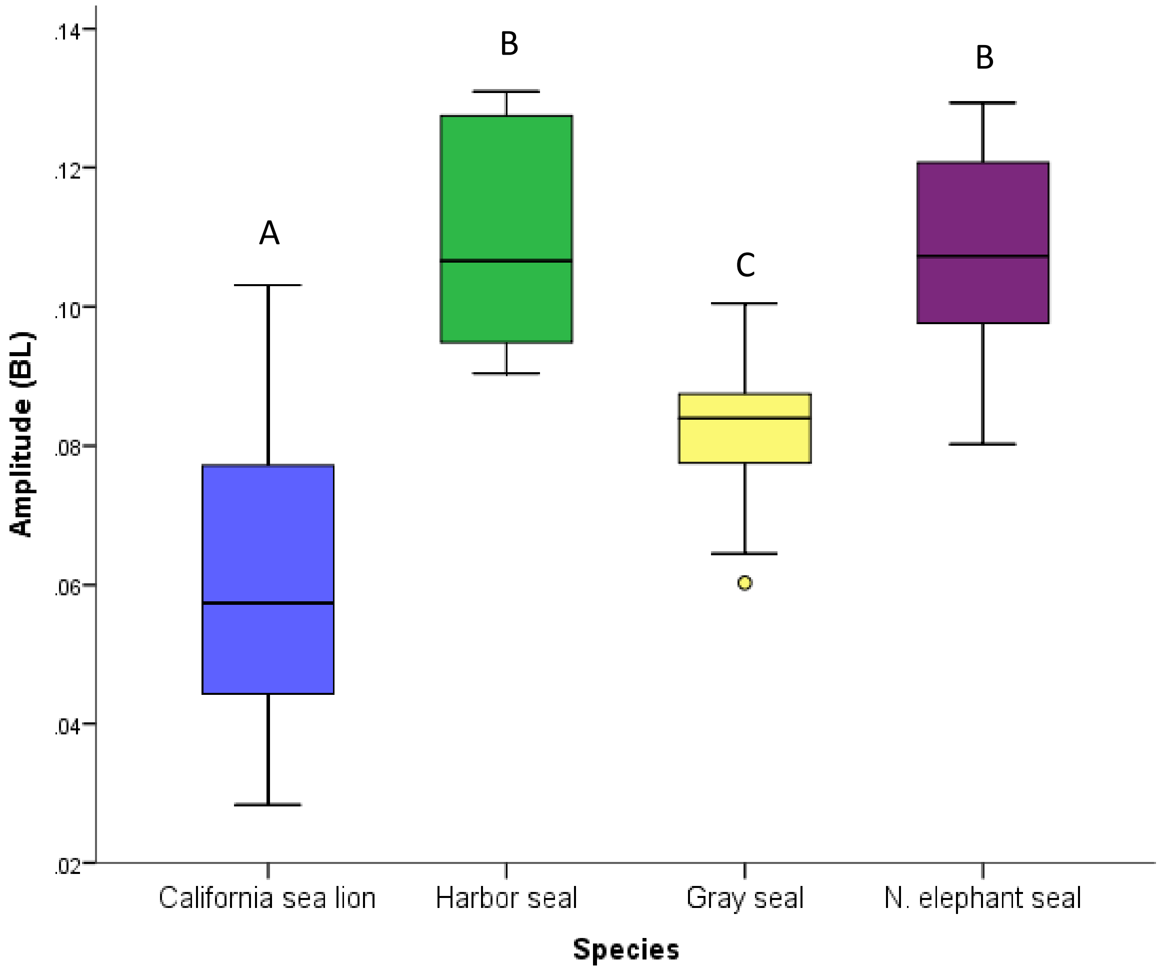
The Northern elephant seals had a Cost of Transport of 1.64 J/kg/m with a Power output of 2,762.41 W



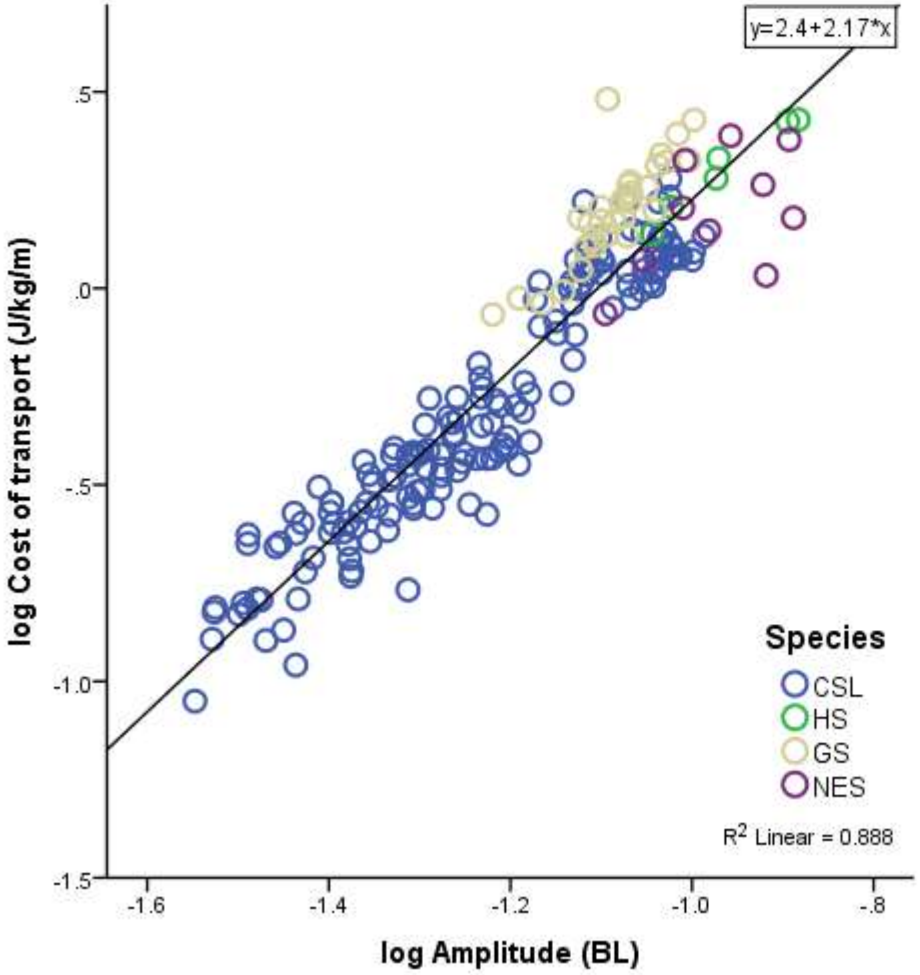


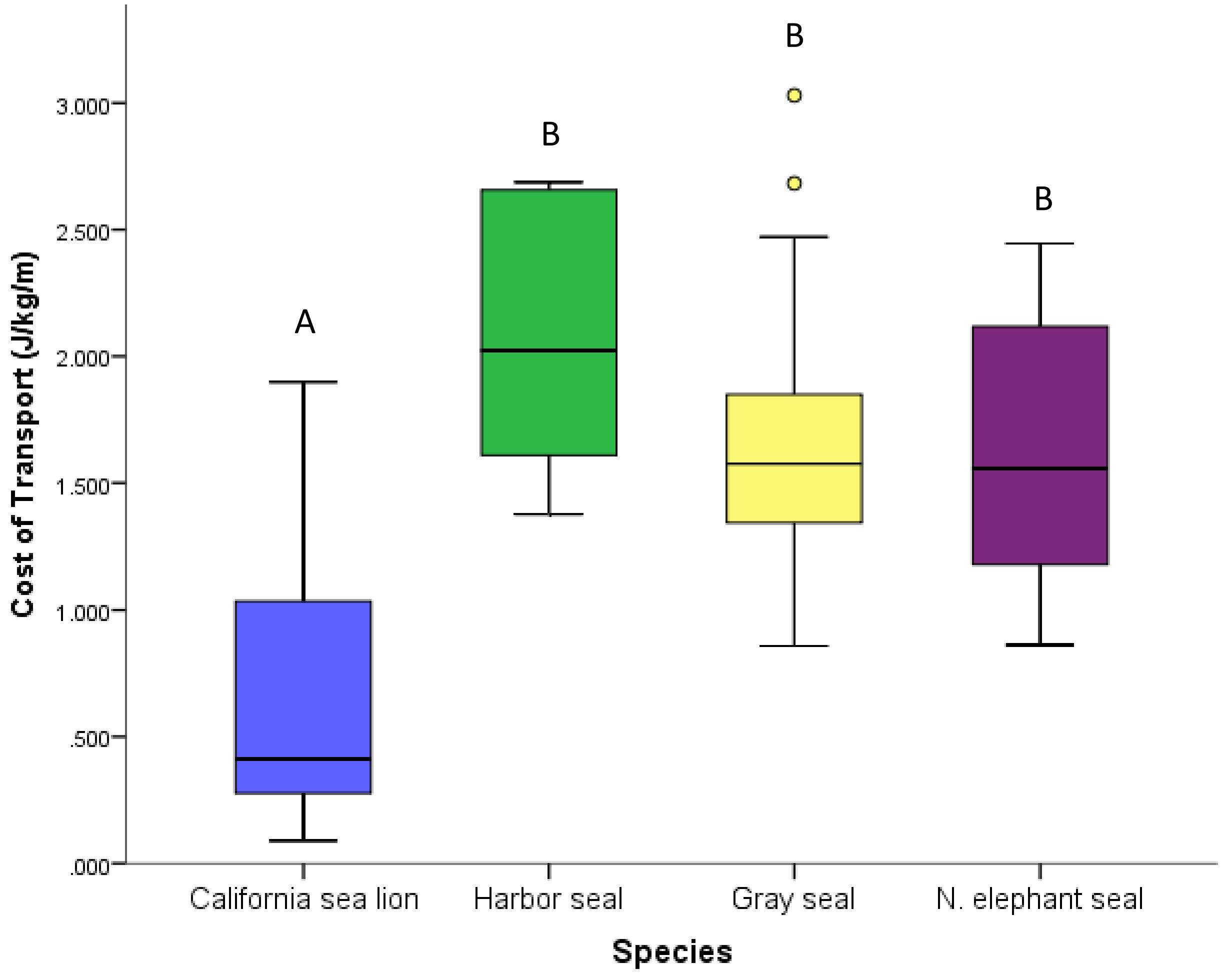
California sea lions had a significantly faster velocity and a lower vertical displacement





California sea lions had a significantly lower Power outputs and a lower Cost of transport





Galloping Efficiency

2.06 J/kg/m

0.63 J/kg/m

0.35 J/kg/m

Conclusions

- California sea lions have the ability to pull their hindlimbs underneath their body to gallop on land
- Sea lions move over land with higher velocities, smaller vertical amplitudes, and thus significantly lower costs of transport and power outputs.
- California sea lion do locomote more efficiently, their gait more similar to the efficient gait of a terrestrial mammal.

Questions?

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