# Metabolic costs of submerged activity in three species of Arctic seals

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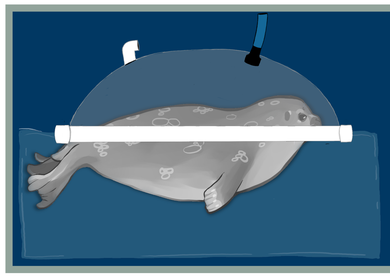
ALASKA MARINE SCIENCE SYMPOSIUM

**BACKGROUND** Arctic seals are physiologically adapted to an amphibious lifestyle, relying primarily on sea ice as haul-out substrate but spending more than half their time submerged. Projected habitat changes emphasize the importance of in-water activities when considering the energy budgets of free-ranging seals, but estimates of activity-specific costs are not available for these ice-dependent marine mammals.

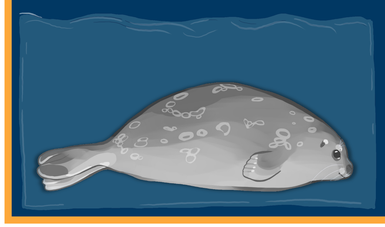
**METHODS** We used open-flow respirometry to compare the metabolic rates associated with resting in water to those incurred during submerged behaviors in five adult seals at the Alaska SeaLife Center in Seward, AK and Long Marine Laboratory, in Santa Cruz, CA. Seals were trained to complete a stationary dive or a submerged swim before immediately surfacing beneath an acrylic metabolic dome to measure the rate of oxygen consumption ($\dot{V}O_2$) during recovery.



**RESTING**

Seals rested calmly at the water's surface while $\dot{V}O_2$ was measured

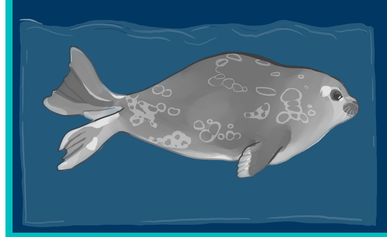
Rest duration was 8- 18 min



**DIVING**

Submerged, stationary diving at the bottom of the pool

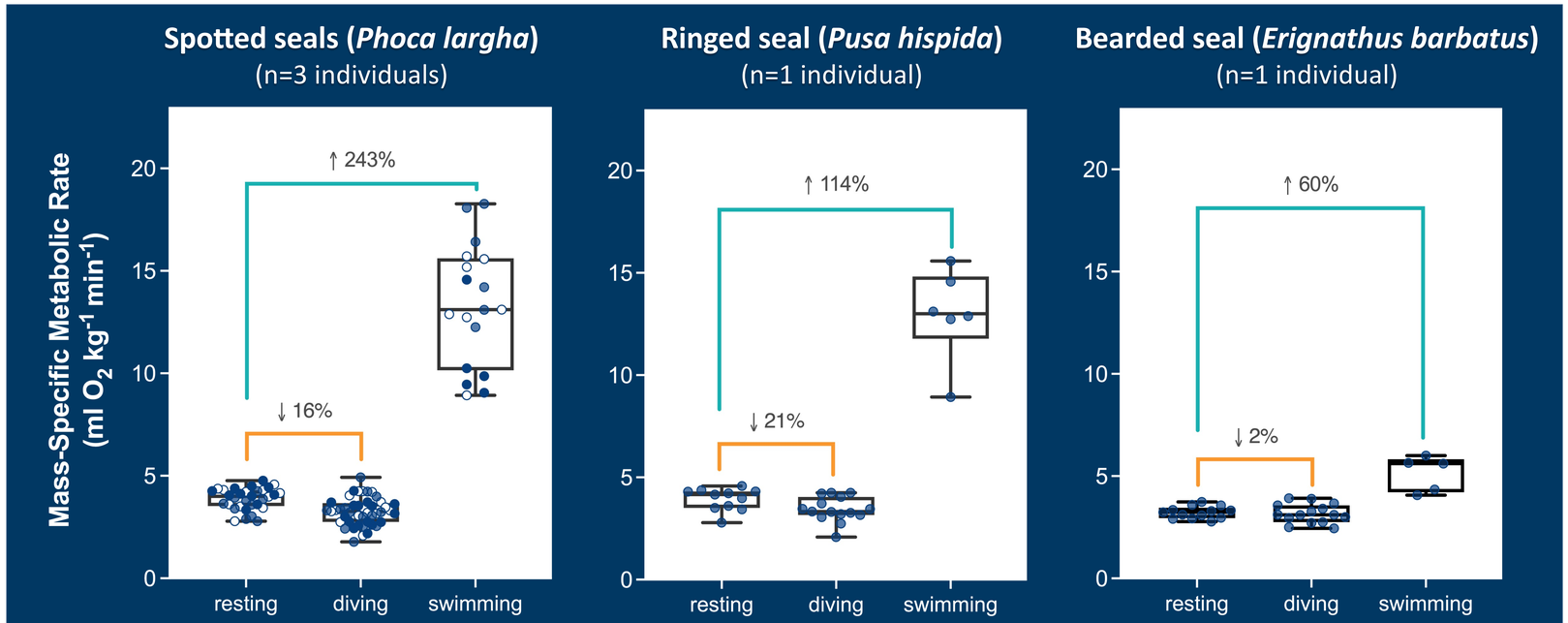
Dive durations were 3, 5, or 7 min



**SWIMMING**

Submerged, continuous swimming along the perimeter of the pool

Swim duration was 2-3 min




Pairwise comparison of **resting and diving** $\dot{V}O_2$ revealed a significant decrease in costs in the spotted ($p<.01$) and ringed seals ($p<.001$), but no difference in $\dot{V}O_2$ in the bearded seal ($p>.05$)

Pairwise comparison including **resting, diving, and swimming** $\dot{V}O_2$ revealed increased costs relative to resting during submerged swimming in all three species (spotted and ringed seals, $p<.001$; bearded seal, $p<.01$)

| | Swim Speed | Cost of Transport |
|---|---|---|
| Spotted seals | 1.4 m $s^{-1}$ | 0.13 ml $O_2$ $kg^{-1}$ $m^{-1}$ |
| Ringed seal | 1.2 m $s^{-1}$ | 0.17 ml $O_2$ $kg^{-1}$ $m^{-1}$ |
| Bearded seal | 0.8 m $s^{-1}$ | 0.11 ml $O_2$ $kg^{-1}$ $m^{-1}$ |

**CONCLUSIONS** Measurements of $\dot{V}O_2$ during diving highlight the decreased energetic costs attributable to the dive response in spotted and ringed seals, and the unique physiological responses of the bearded seal. These results from relaxed, cooperating individuals help to explain how seals manage conflicting pressures of metabolic suppression during diving and elevated oxygen requirements of exercise. The costs of diving and submerged swimming can now be considered in quantitative models of ice seal energy budgets to inform how species differences will influence tolerance of individuals and populations to changing Arctic conditions.

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