



The search for widely-applicable methods to measure body condition of diving animals:

three at-sea metrics of body density validated in northern elephant seals

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Body condition (lipid content or mass)



 Integrated outcome of foraging success and metabolic expenditure

- Predictor of survival and reproductive success
- Influences foraging effort and reactions to predation risks, disturbance

(Hall et al., 2001; Moya-Laraño et al., 2008; McNamara & Houston, 1990; Beale & Mohaghan, 2004; Biuw et al., 2003)















Body <u>Component</u> Lipid Protein Ash Water





plethysmography (Fields et al. 2005)



measuring condition at sea



identifies when/where foragers accumulate resources
can be applied to fully-aquatic animals (cetaceans)





How to track condition of other marine taxa?





How to track condition of other marine taxa?



Gliding during transit is a widespread behaviour

(Williams et al., 2000; Nowacek et al., 2003)









Baikal seals terminal speed of prolonged descent gides (Watanabe et al., 2006)

ARKIVE







A.) Test the consistency of the three methods over a range of body densities

- 1. Drift dive
- 2. Prolonged glide
- 3. Glide



B.) Compare with density from isotope dilution

C.) Evaluate advantages and disadvantages of each of the methods











<u>3MPD3GT</u> (Little Leonardo)

depth

water temperature

speed

3-axis acceleration (pitch and hind flipper movements)



trans-location experiment



Ano Nuevo State Reserve **Release** Point Data SIO, NOAA, U.S. Navy, NGA, GEBCO

<u>Body density</u> calculated from isotope dilution

manipulated over range of interest

> (a weight and float detached after 8-16h by a timerrelease)









glide method



 \mathbf{C} d,f $A\!f$ + $O_{\rm SW}U$ a m

measiitedivalues Reg<mark>glides ≳n10</mark>0m - uspitchz≥n30°glides





glide method: data







glide method: data





University of St Andrews





Floated-and-weighted condition in seal 2











All 3 methods matched isotope-dilution method - density ±1%, predicted lipid content ±2%

| <u>Approach</u> Drift Dive | <u>Advantages</u> requires only depth/speed | <u>Dis-advantages</u> Cd not estimated limited applicability |
|-------------------------------|--|--|
| Prolonged | Cd estimated | buoyancy extremes high-resolution speed |
| Glide | widest applicability Cd estimated | high-resolution speed |







All 3 methods matched isotope-dilution method - density ±1%, predicted lipid content ±2%

Methods applicable to a wide-range of speciesOptimal method depends on behaviourGas effects important for shallow-divers

Aoki et al., in press, J. Exp. Biol.

Thank you!

Año Nuevo State Reserve & UCSC students

National Environment Research Council University of Tokyo (UTBLS) Japan Society for the Promotion of Science (JSPS) National Ocean Partnership Program Office of Naval Research Moore, Packard, and Sloan Foundations

All procedures used were approved by the UCSC CARC (IACUC) and permitted under NMFS marine mammal permits

Photo: Lars Boehme



prolonged glide: terminal speed





F_{buoyancy} x sin(pitch) = F_{drag}



prolonged glide: example





weighted condition in seal 4





Body density manipulations

| | Condition | Measured body denisty (kg m ⁻³) | Water density; 1027-1031 kg m ⁻³ | |
|-------|--|--|--|--|
| seal1 | weigted unattached | 1062.3 1038.9 | | |
| seal2 | floated-and-weigted floated unattached | $\begin{array}{c} 1038.2\\ \hline 1015.4\\ 1038.2 \end{array} \rightarrow$ | positive buoyancy | |
| seal4 | weigted unattached | 1059.8 1040.2 | | |





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