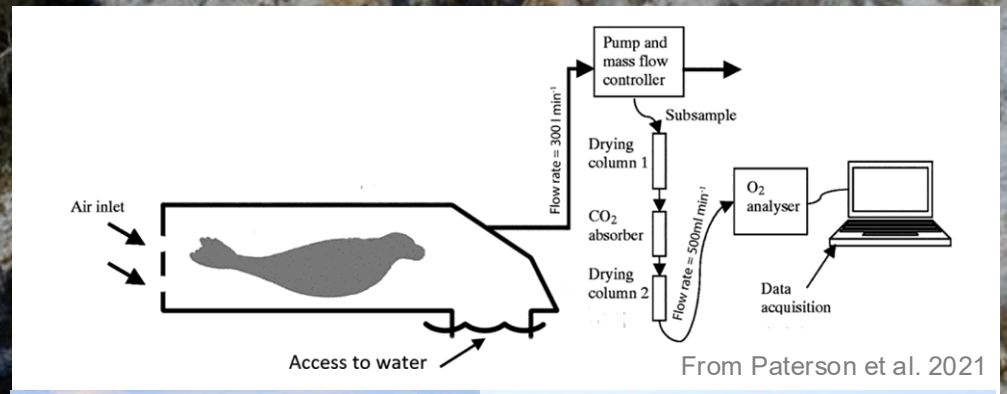
Harnessing emerging technologies for a non-invasive approach to marine mammal energetics

Michelle Shero

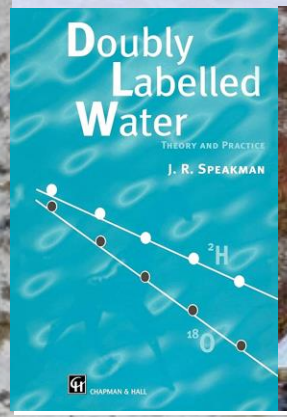
WOODS HOLE OCEANOGRAPHIC INSTITUTION

Tracking Energy Dynamics

- Energetic Expenditure↔Environment
- Traditional techniques are invasive, time intensive and logistically difficult, & costly
- Collecting measures on more than just a few individuals becomes unwieldy

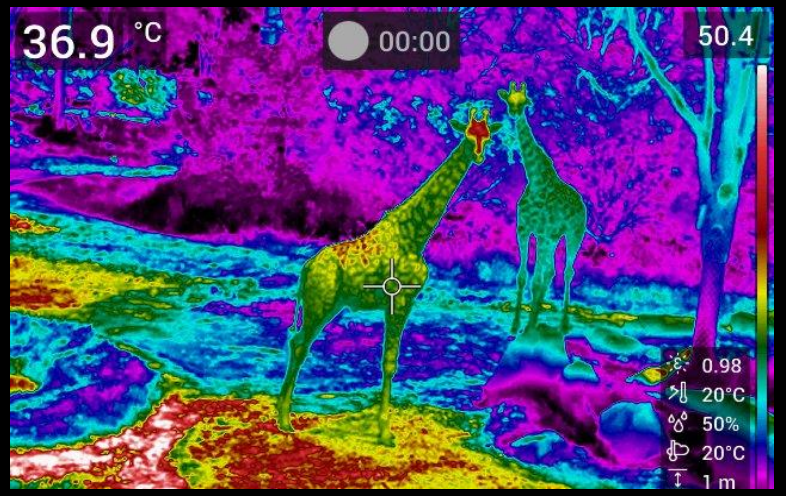


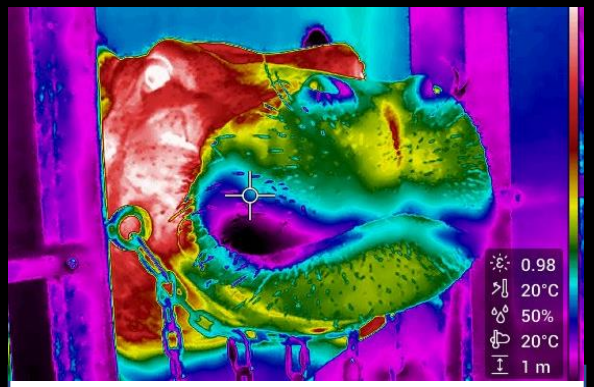
From Paterson et al. 2021




J Erlenbach

Infrared Thermography for Indices of Metabolic Rate



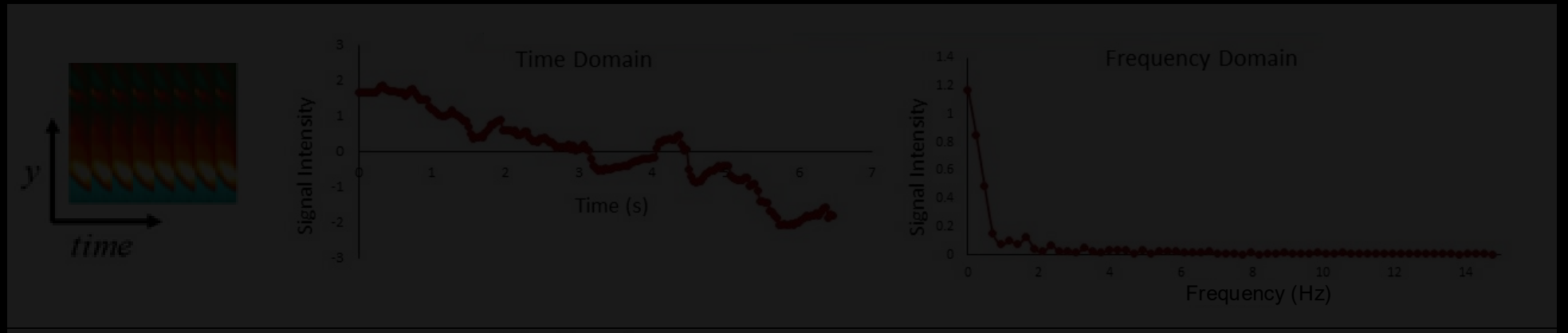


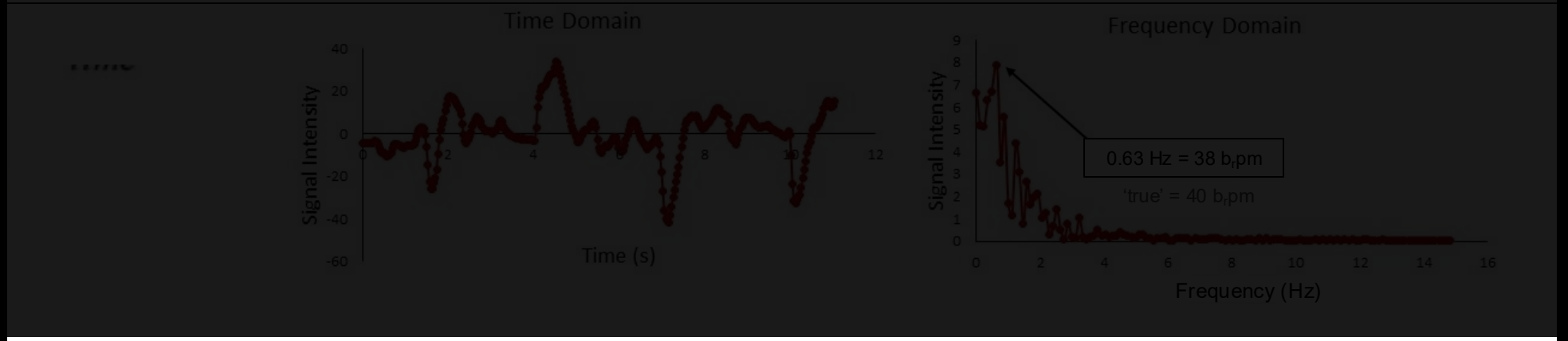
CINCINNATI ZOO & BOTANICAL GARDEN

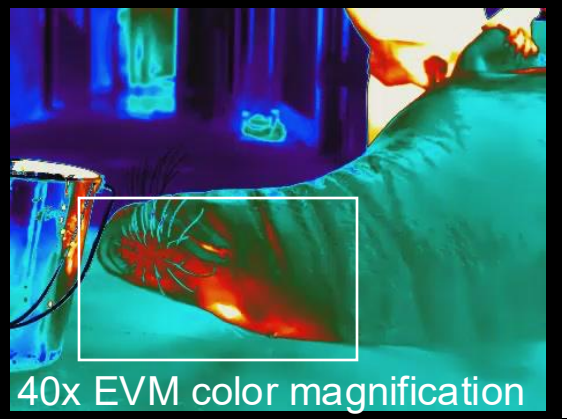
CREW

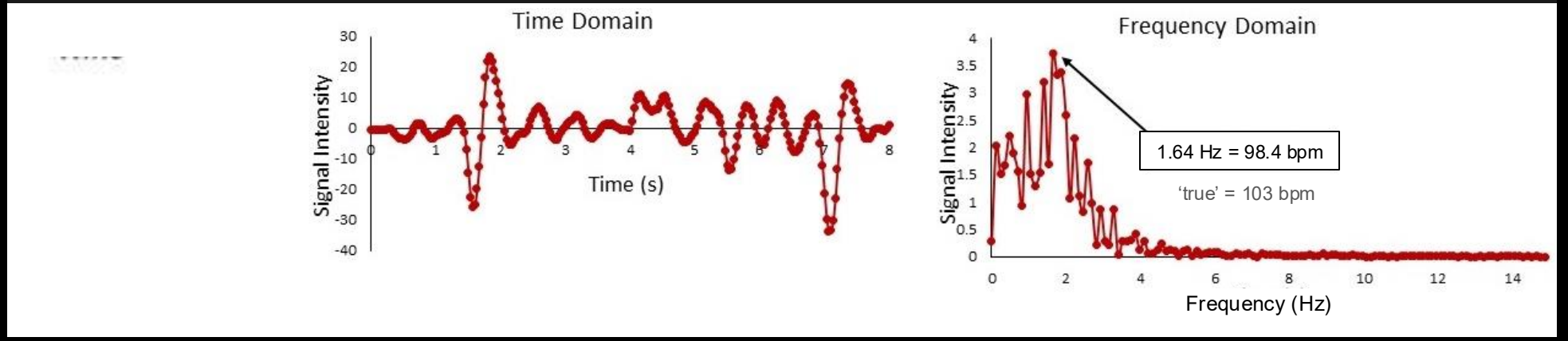
Rzucidlo, Curry, Shero – 2023, BMC Biology

Pulling out subtle physiological signals





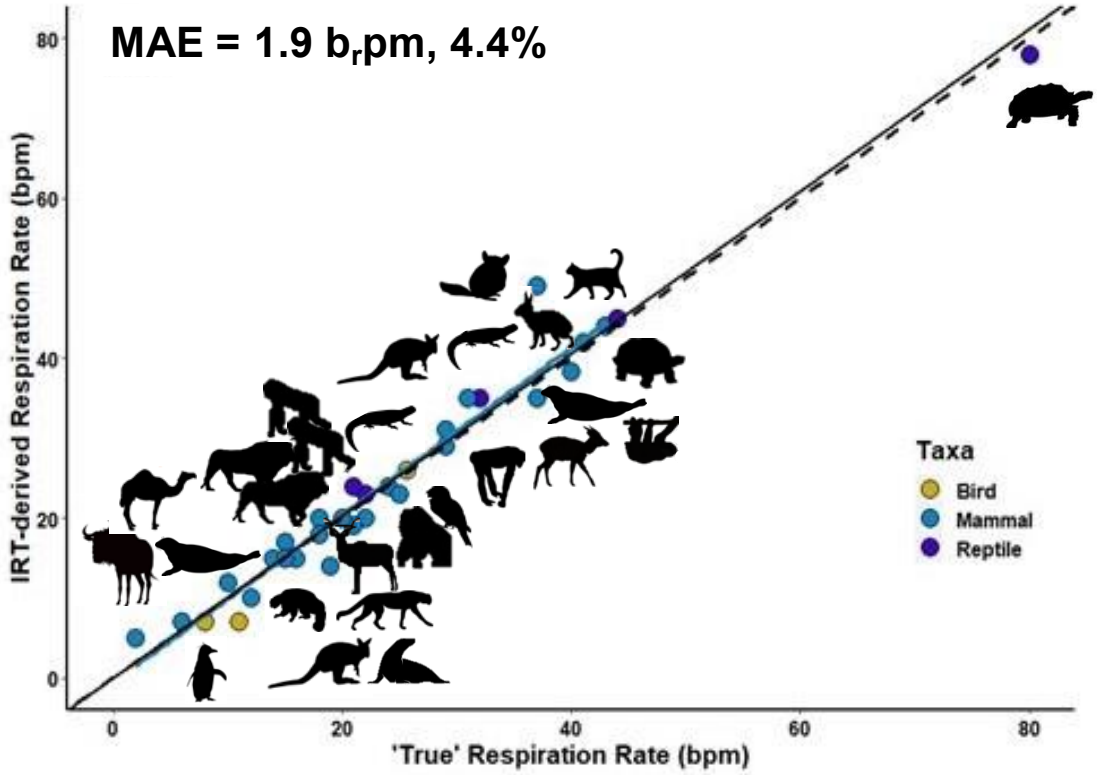




IRT-derived vital signs across species

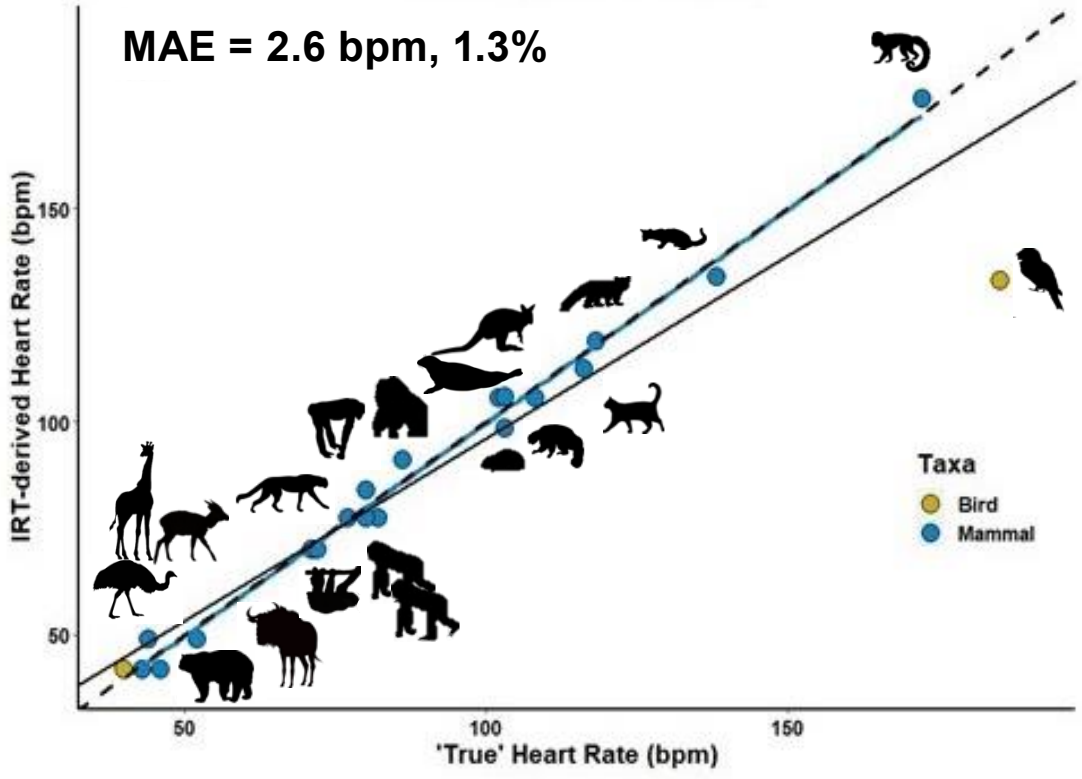
Respiration Rate

Mammal (n = 33) 84.8%
Bird (n=6) 50%



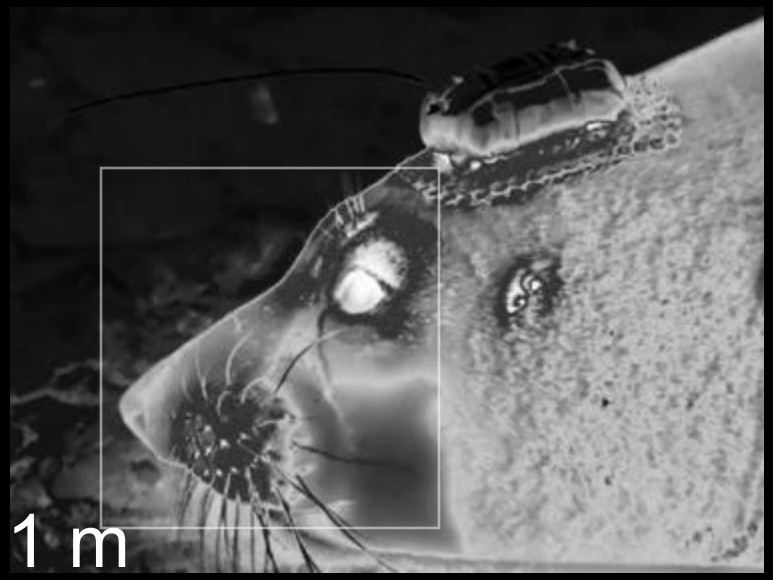
Heart Rate

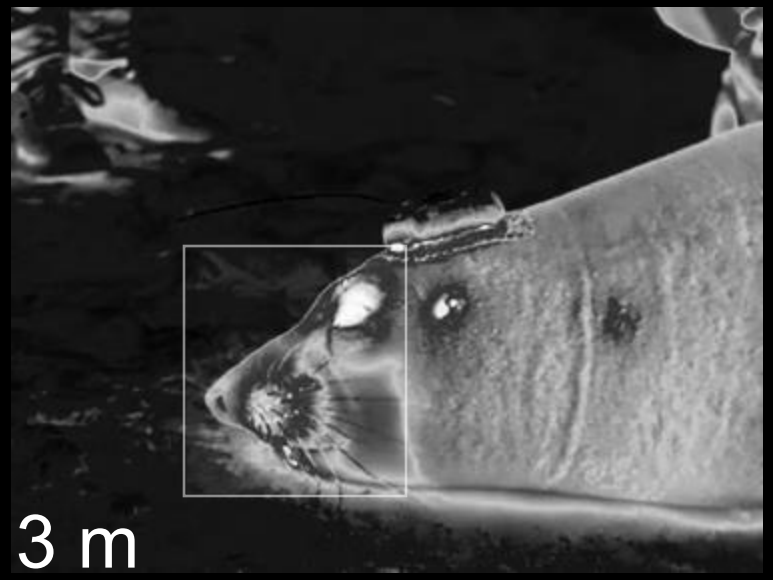
Mammal (n = 33) 66.7%
Bird (n=6) 33.3%

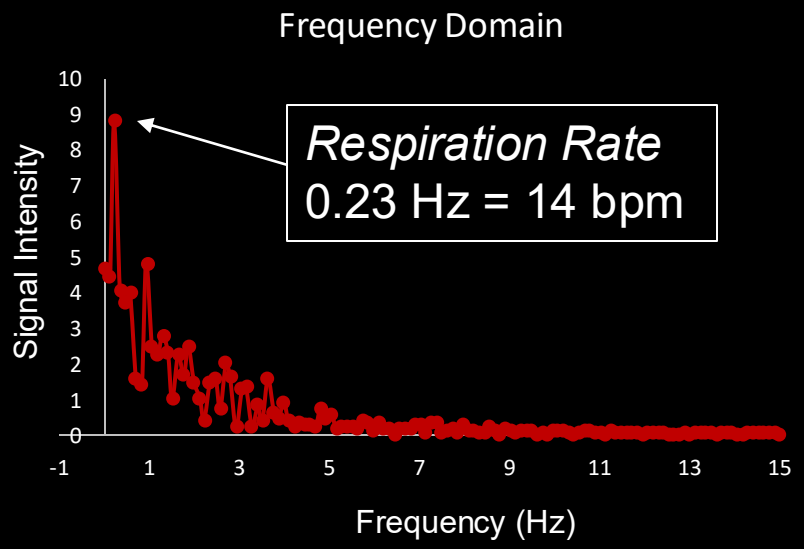


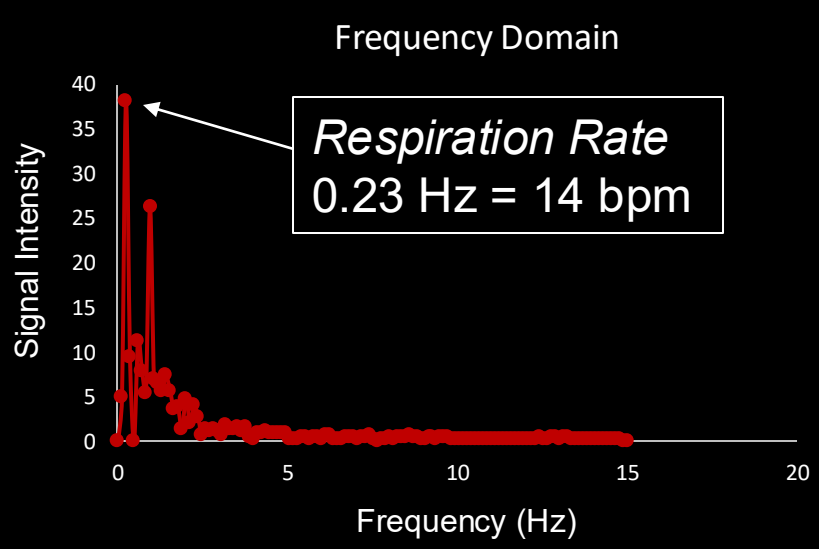
Rzucidlo, Curry, Shero – 2023, BMC Biology

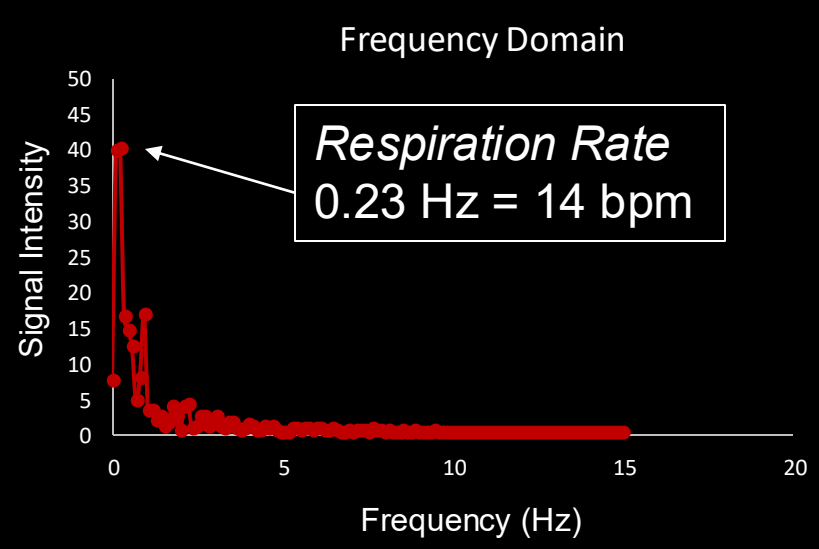
Repeatability & Range







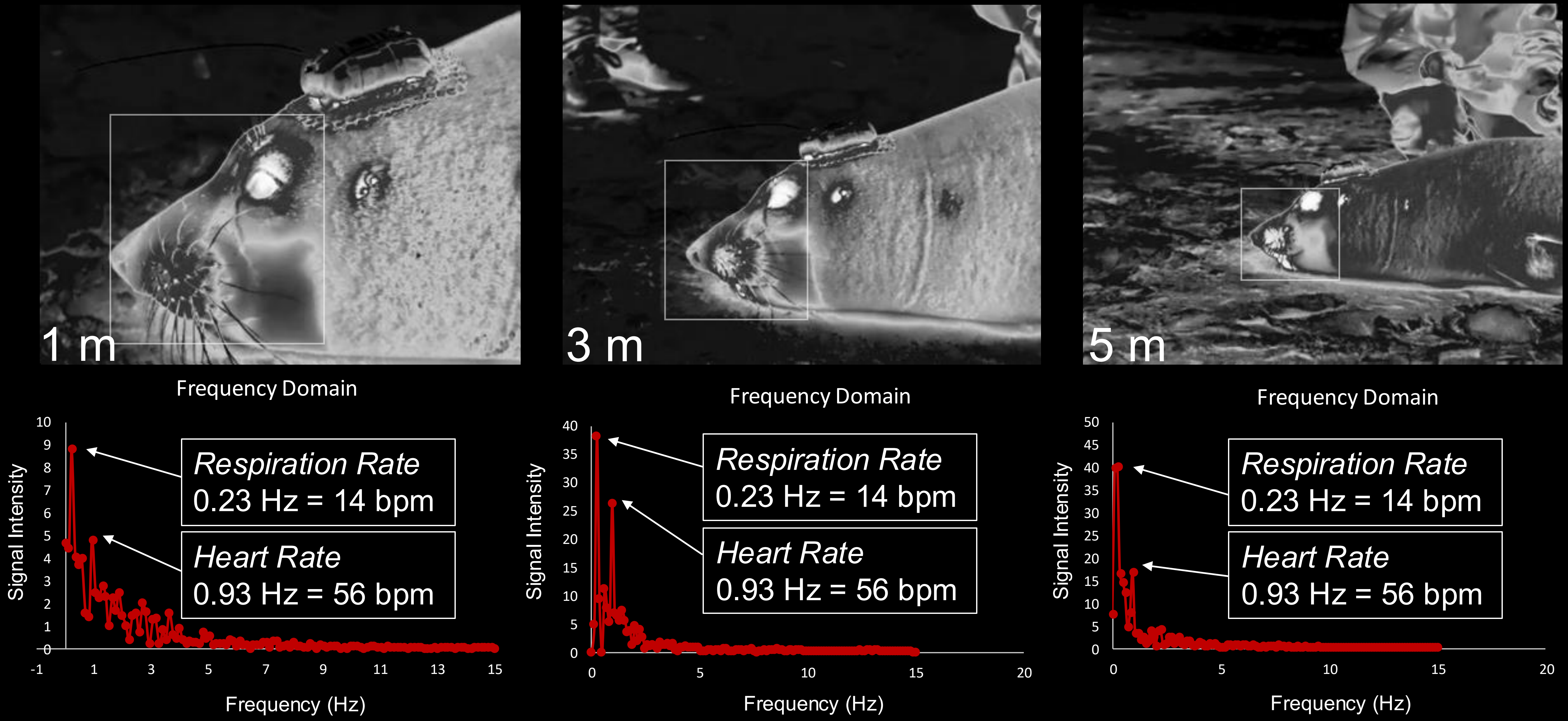




Northern elephant seal, True RR = 12 bpm

Rzucidlo et al. *Under Review*

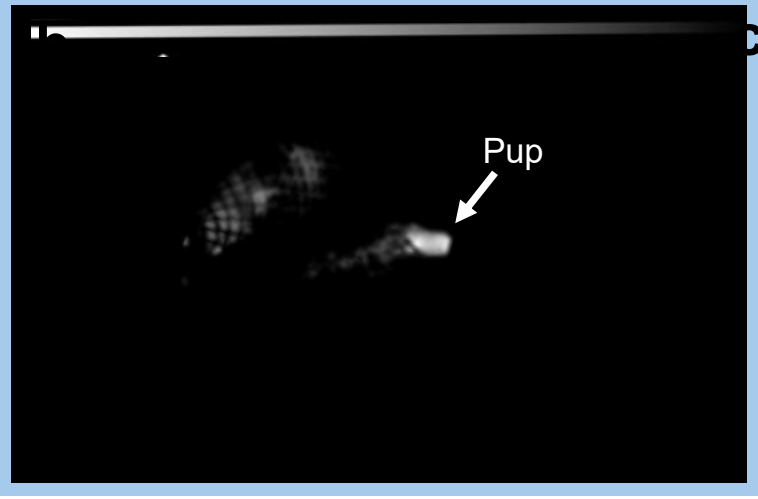
Repeatability & Range

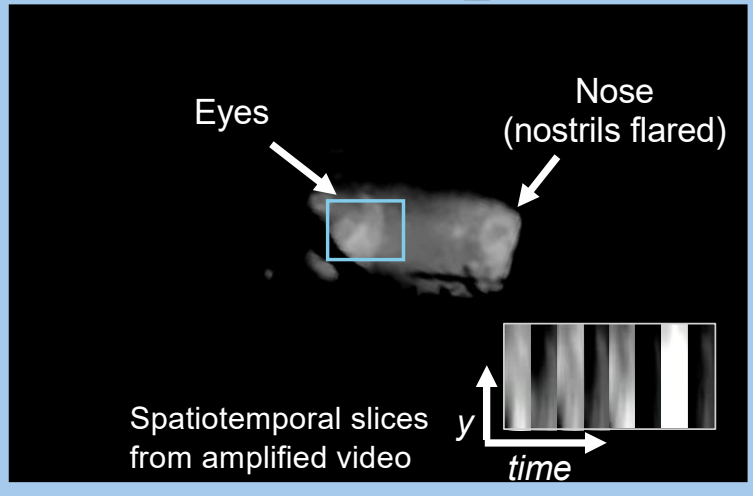


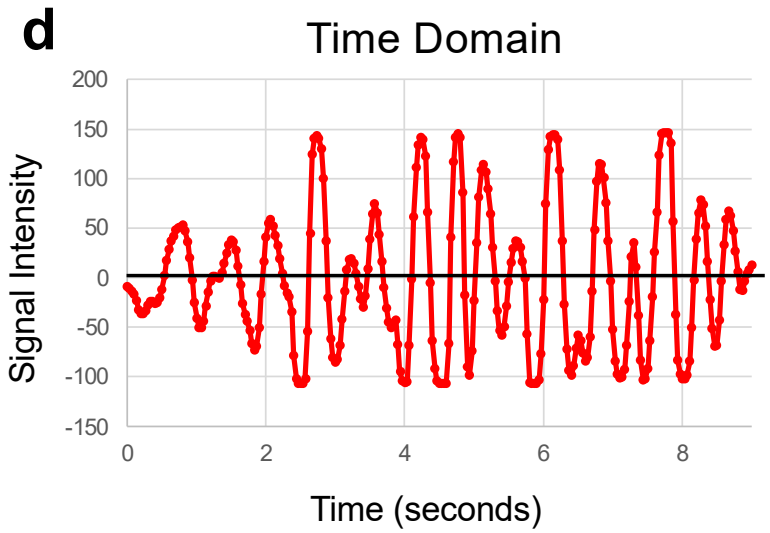
Northern elephant seal, True RR = 12 bpm; True HR = 59 bpm

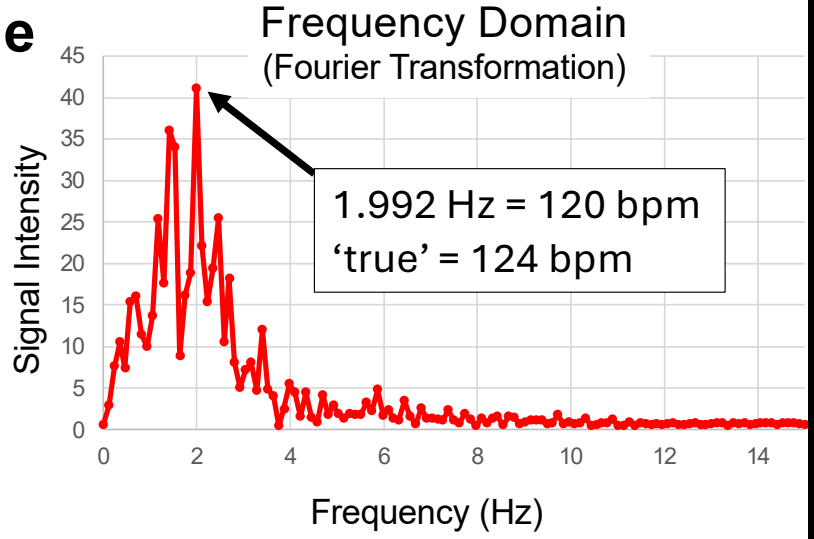
Rzucidlo et al. *Under Review*

Increasing Distance

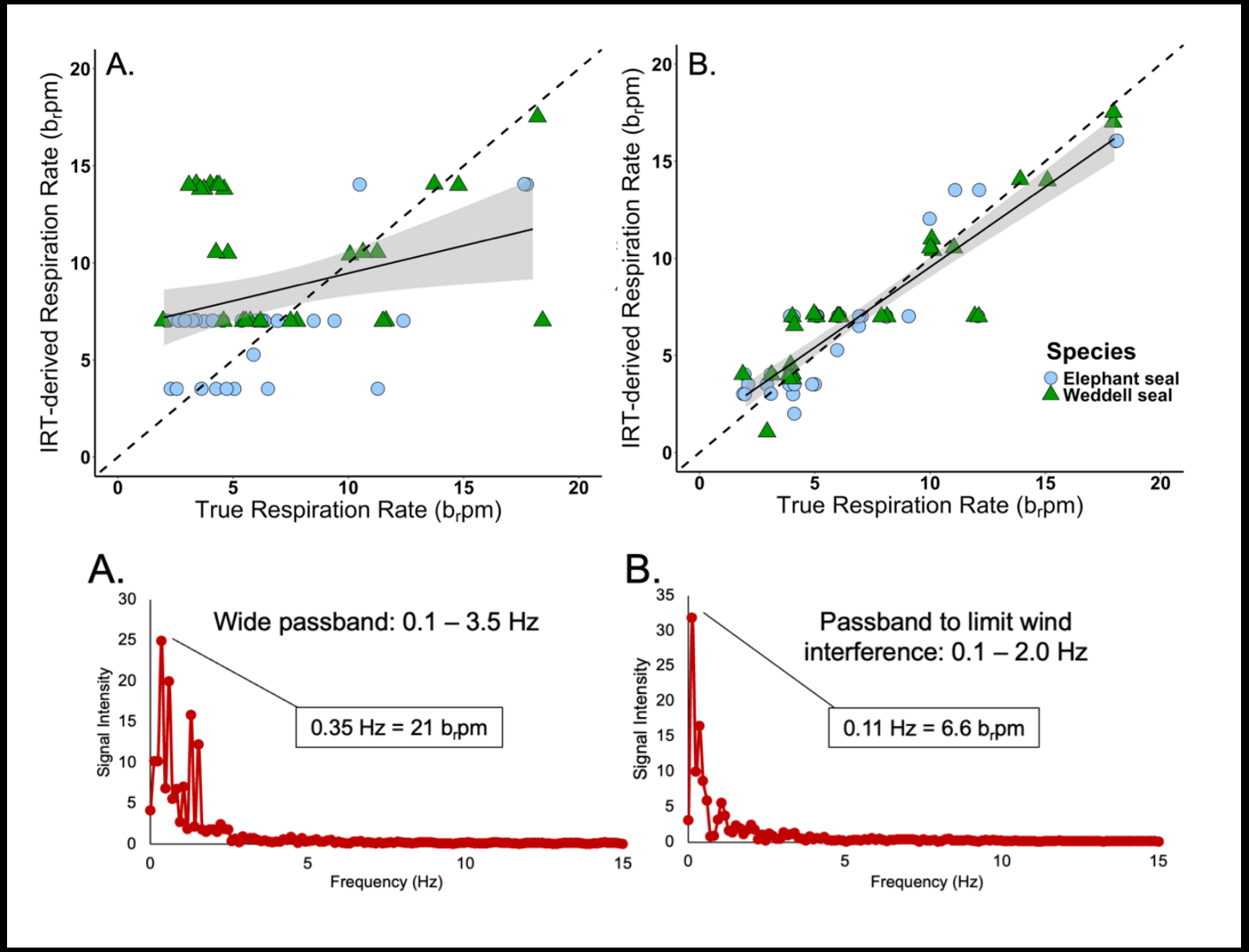






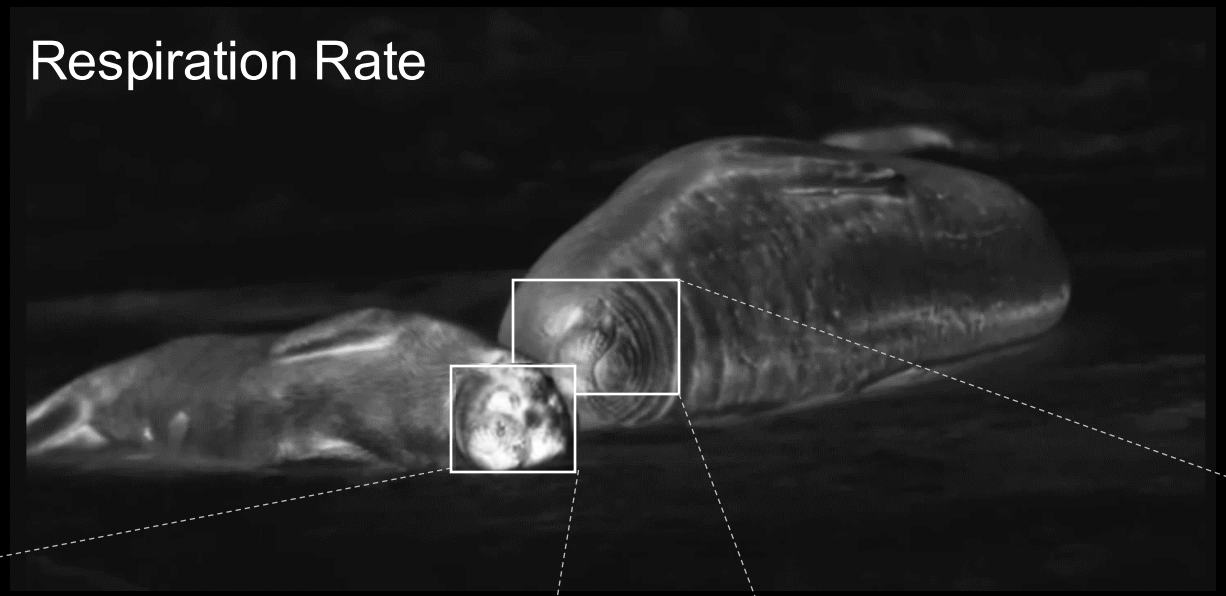


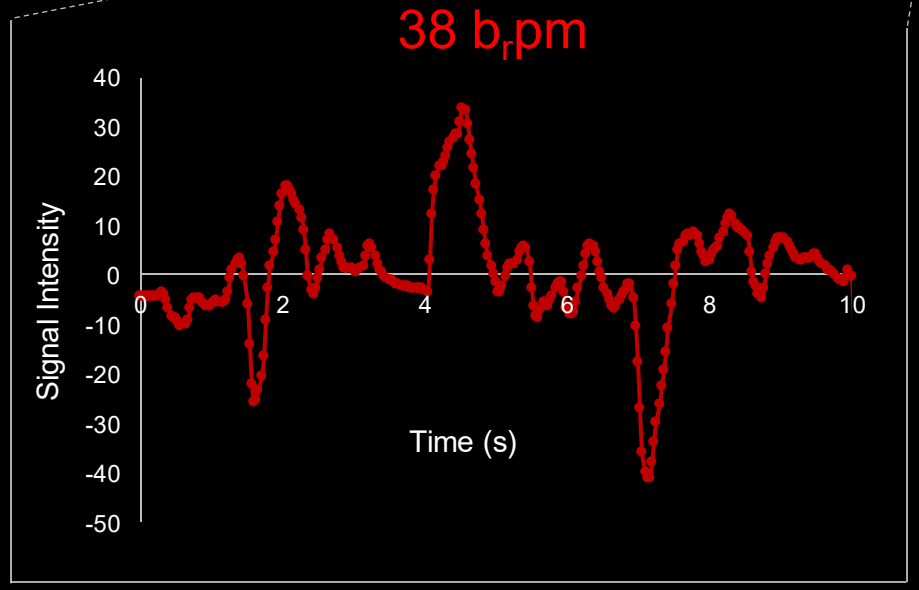
Variable Environment

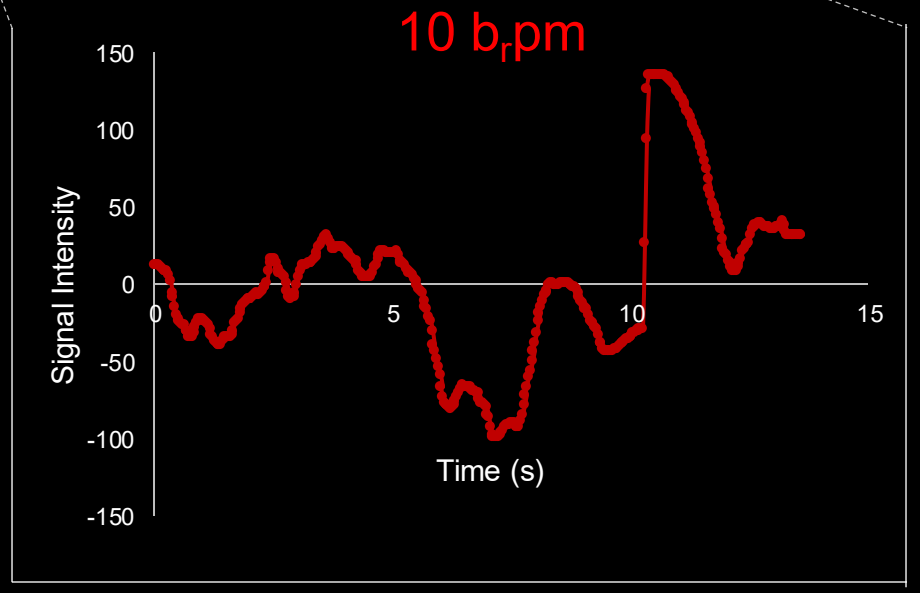


Rzucidlo et al. *Under Review*

Application to Free-Living Animals

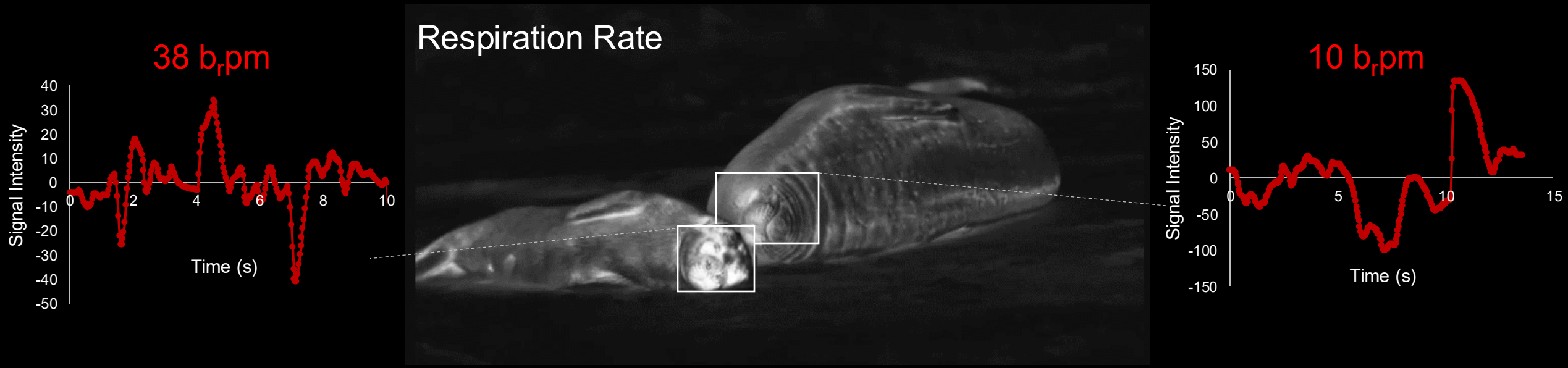






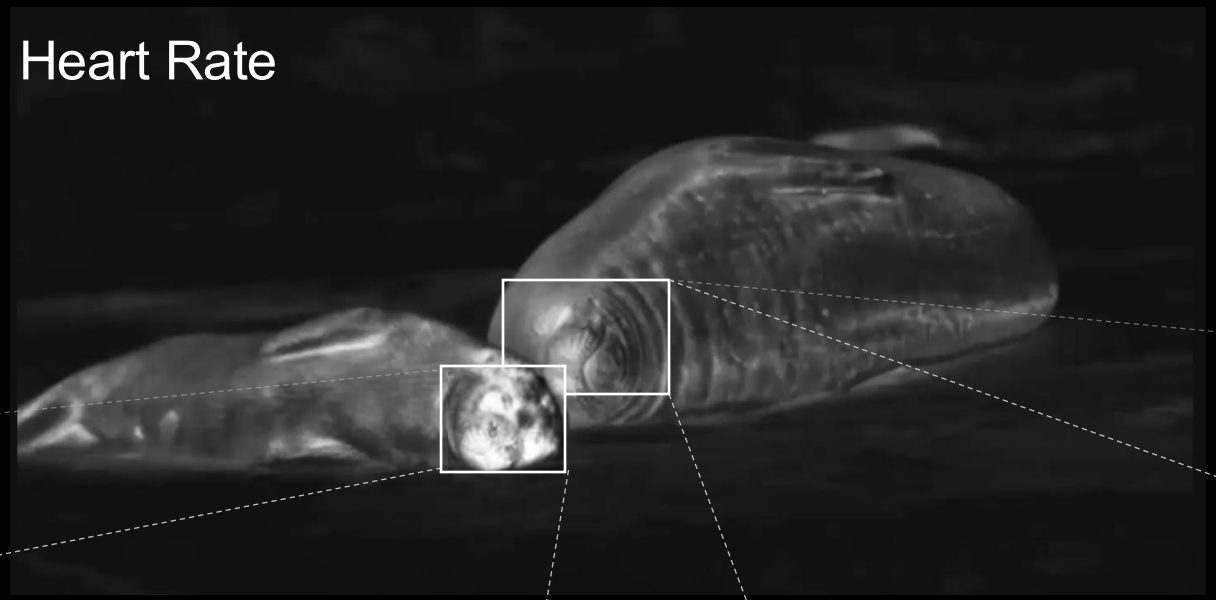
Weddell seal

Application to Free-Living Animals

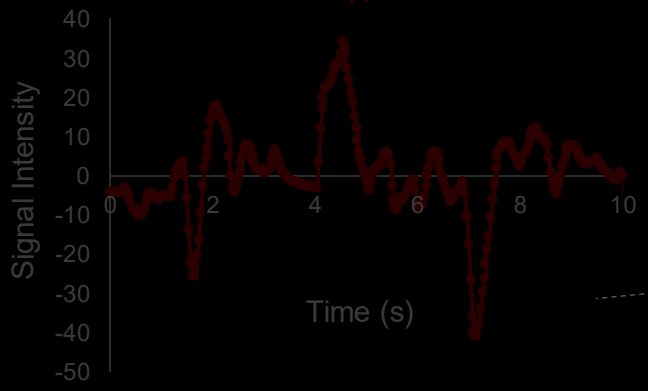


Weddell seal

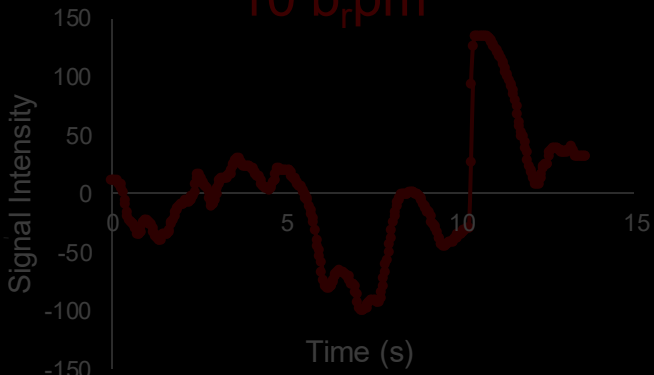
Application to Free-Living Animals



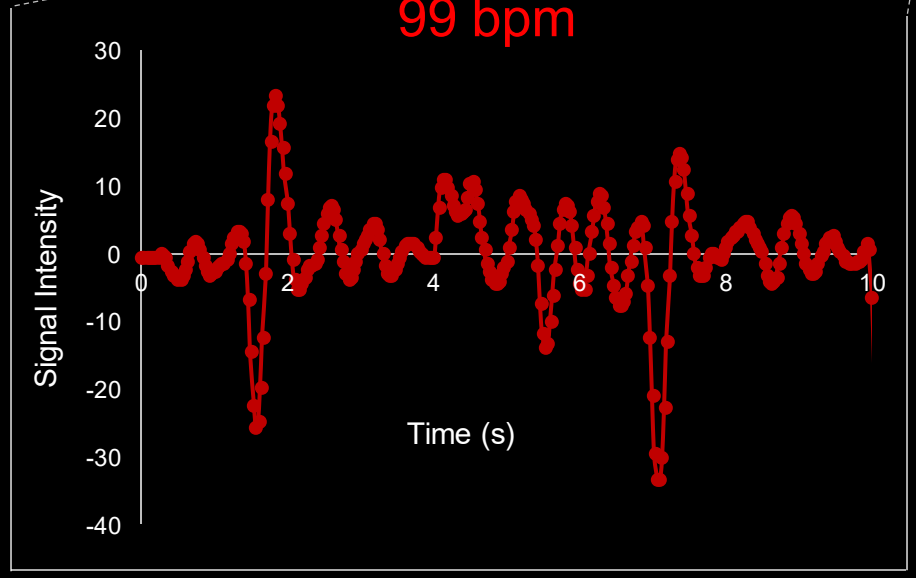
38 b$_r$pm



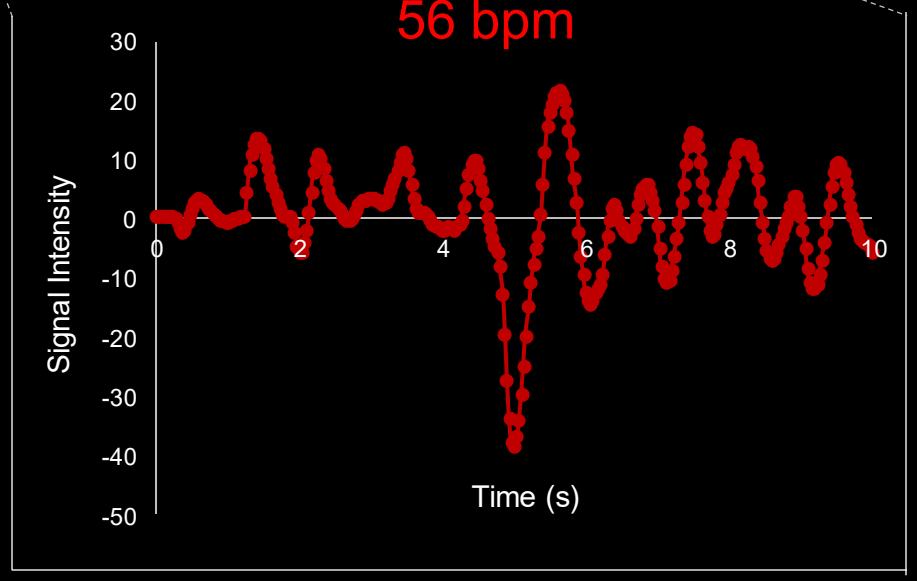
10 b$_r$pm



99 bpm

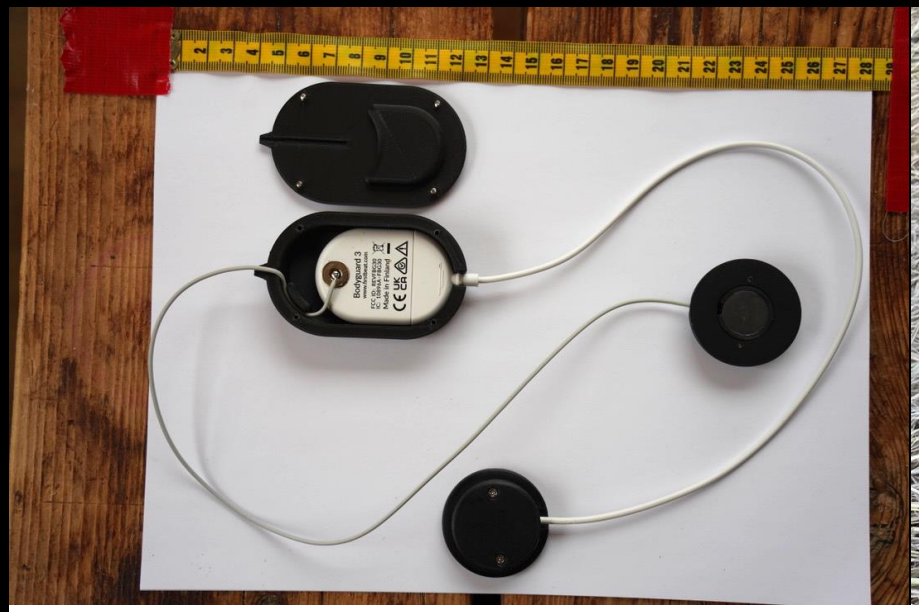


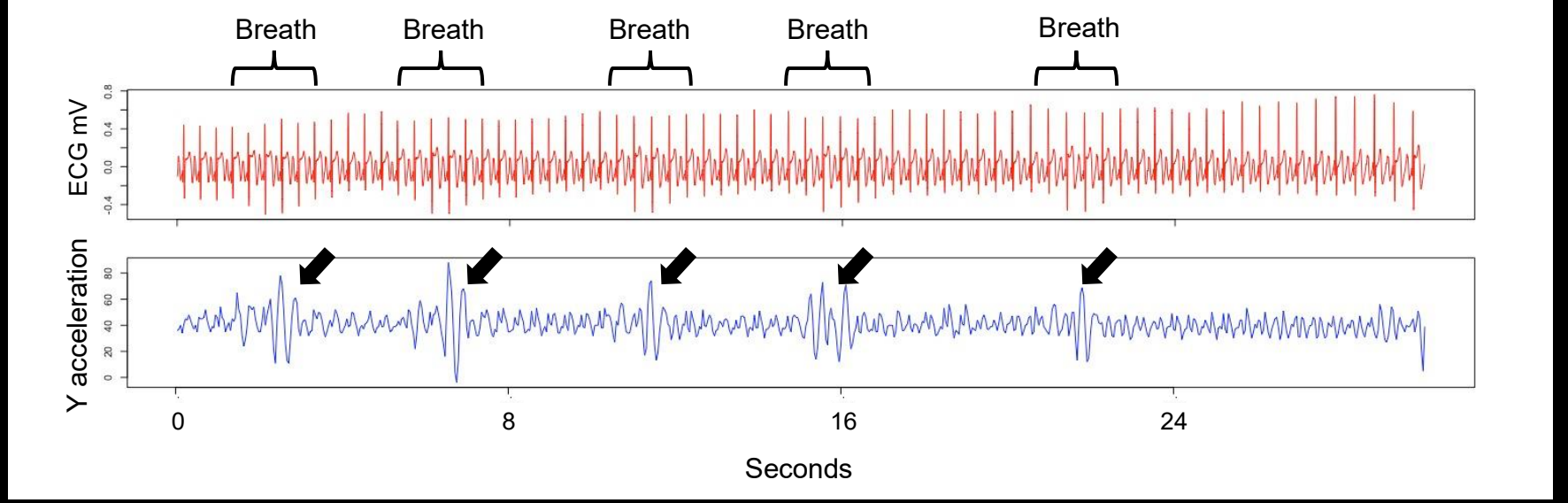
56 bpm



Weddell seal

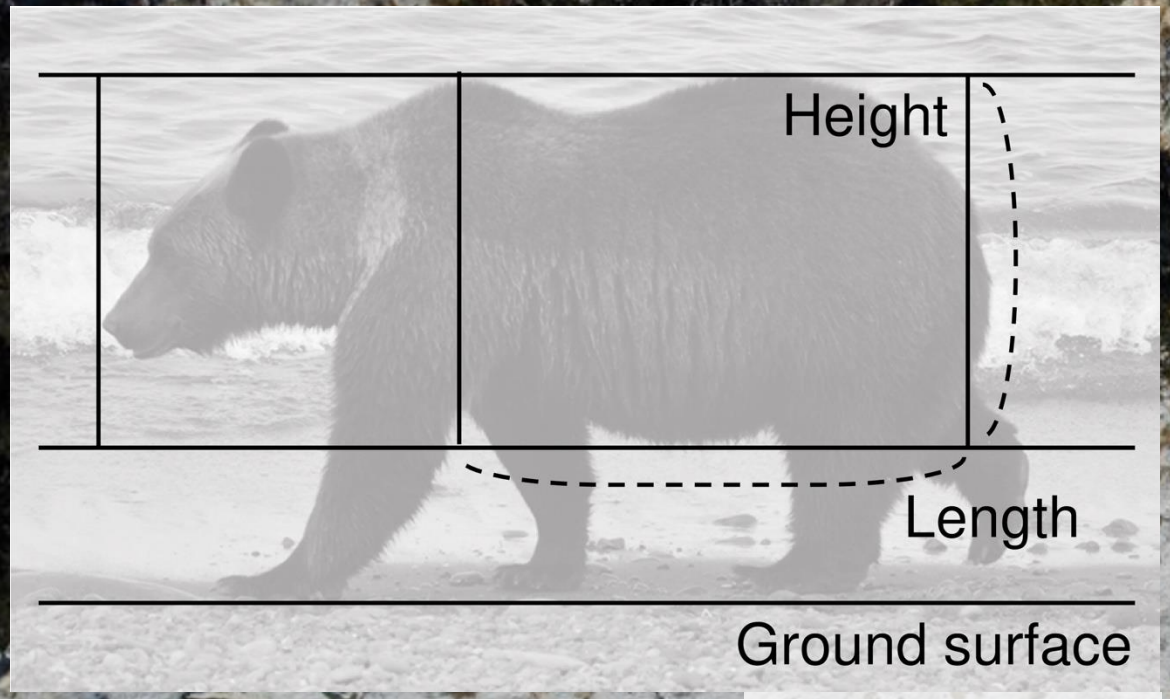
‘Fitbits’



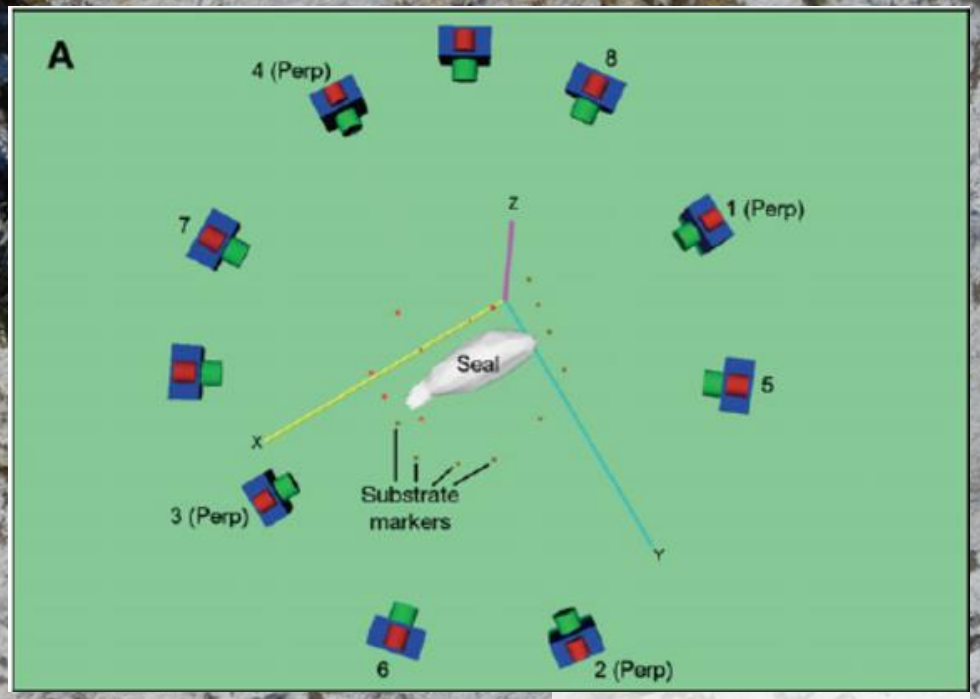


M. Shero

Ways to Measure Body Size and Condition - Photogrammetry



Shirane et al. 2020



De Bruyn et al. 2009

Taking to the Air

Bierlich et al. 2021

Photo: Dave Johnston's lab

Taking to the Air

Taking to the Air

Fisheries and Oceans Canada

Pêches et Océans Canada

Duke | NICHOLAS SCHOOL OF THE ENVIRONMENT

DUKE UNIVERSITY MARINE LAB

Structure from Motion (SfM) Approach

- 360-degree flight plan (orbit mode), at 20-40m altitude
- Oblique angle photographs to capture low-profile animal shape

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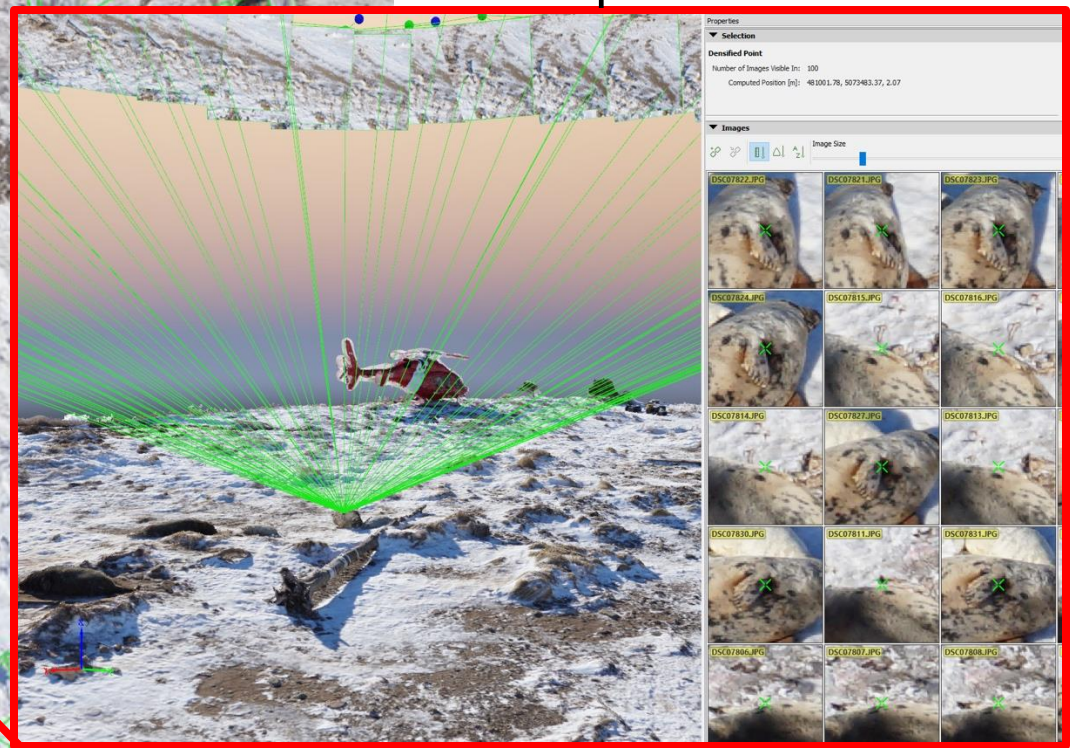
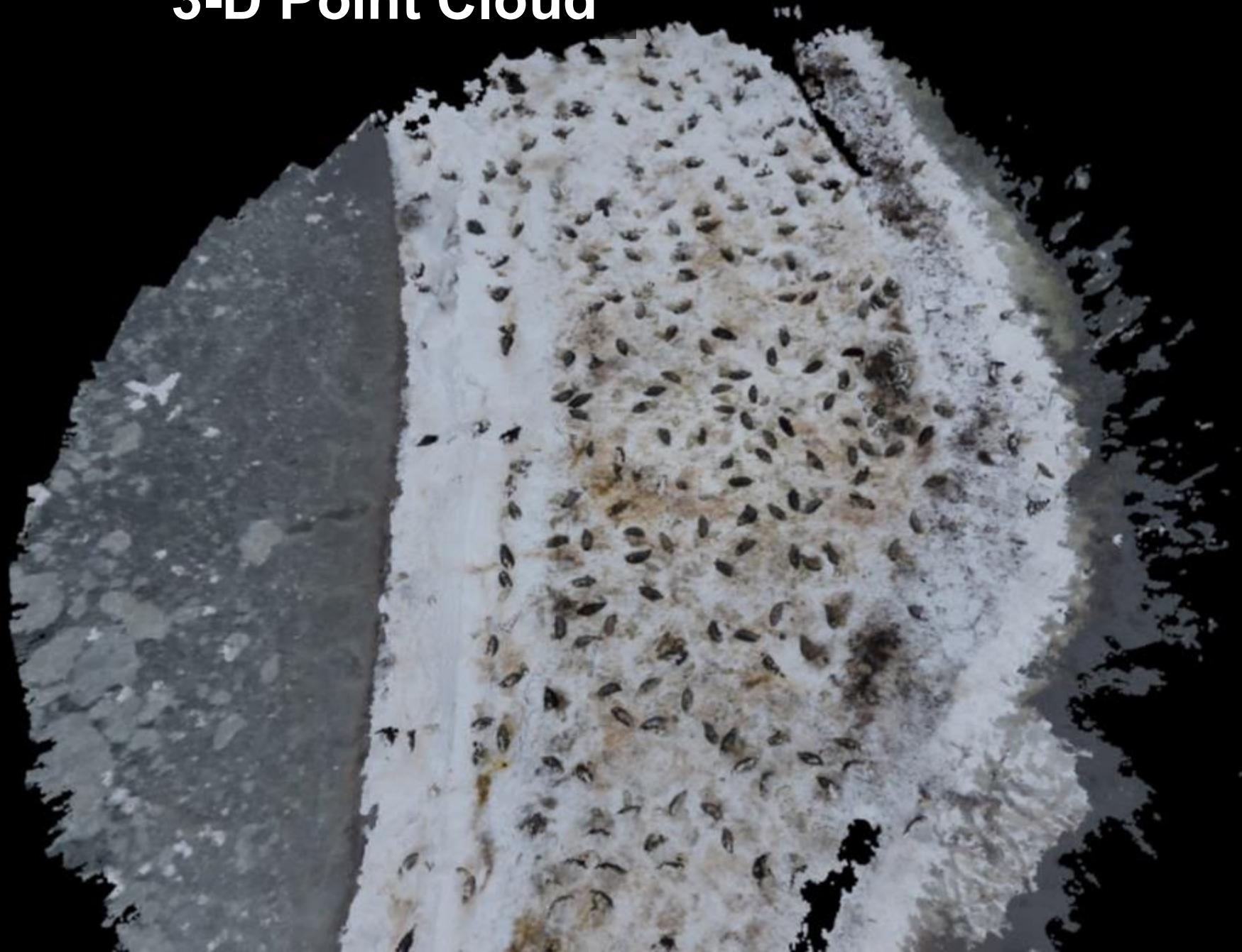
Pix4Dmapper

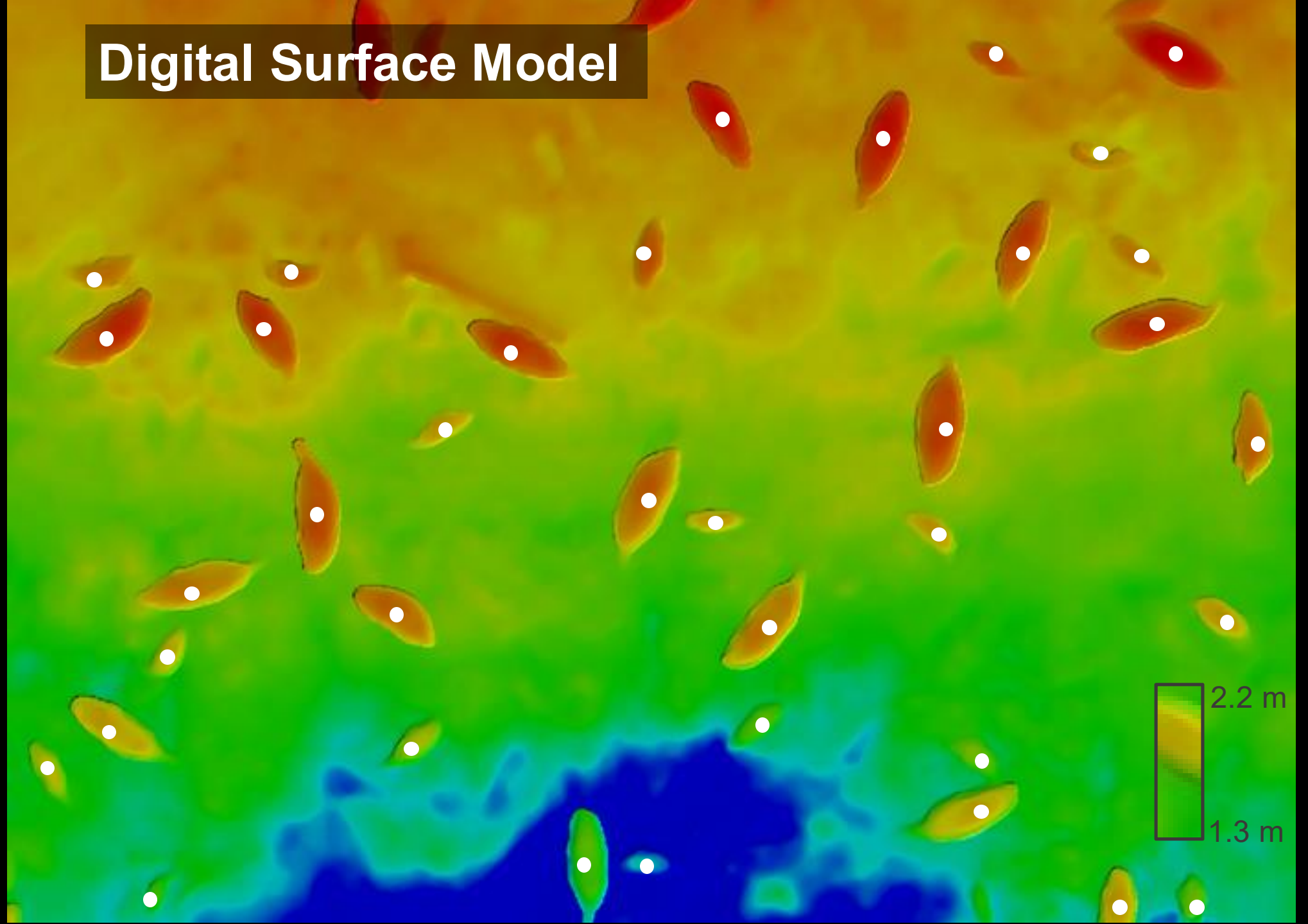
- Custom-code for geotagging images
- 3-D model: Required that each point be re-projected from >=5 photos to be incorporated

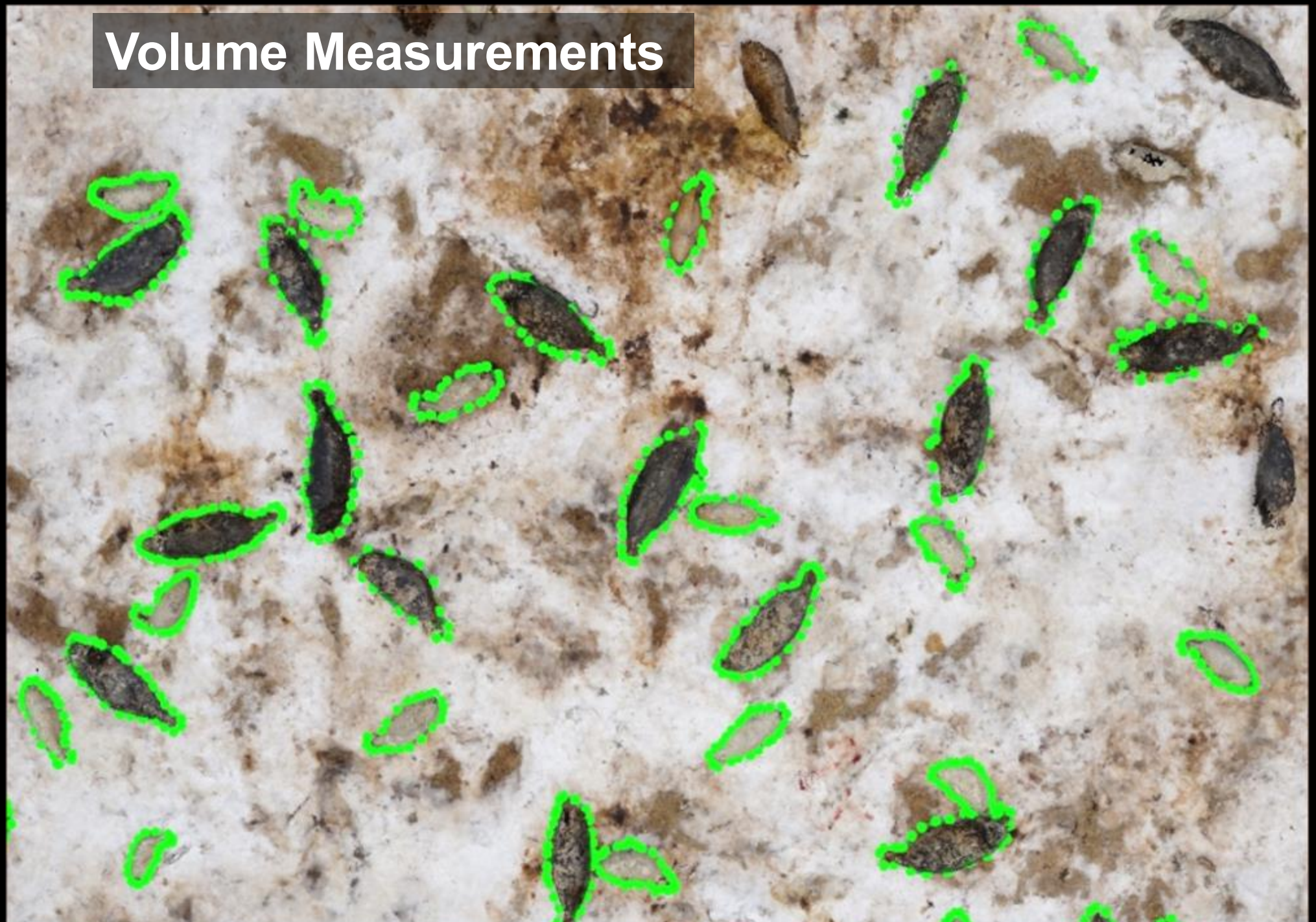


3-D Point Cloud




Orthomosaic

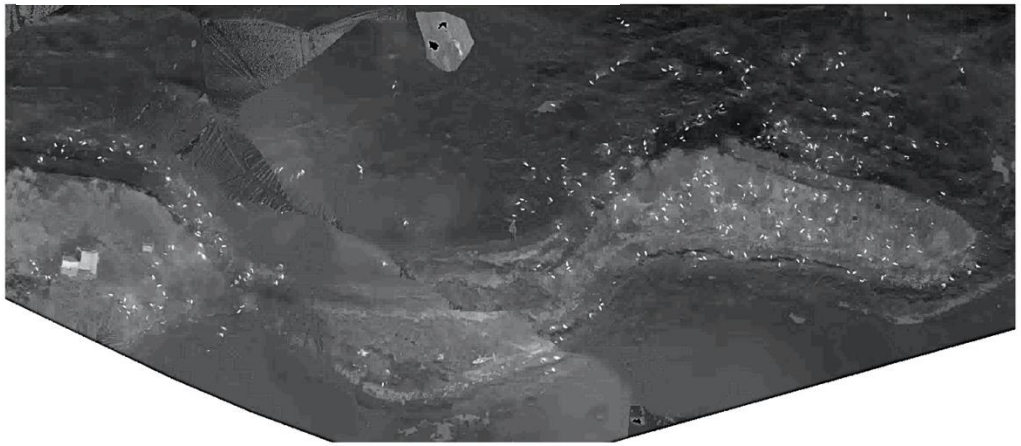

Digital Surface Model
2.2 m
1.3 m


Volume Measurements

Very Different Study Years

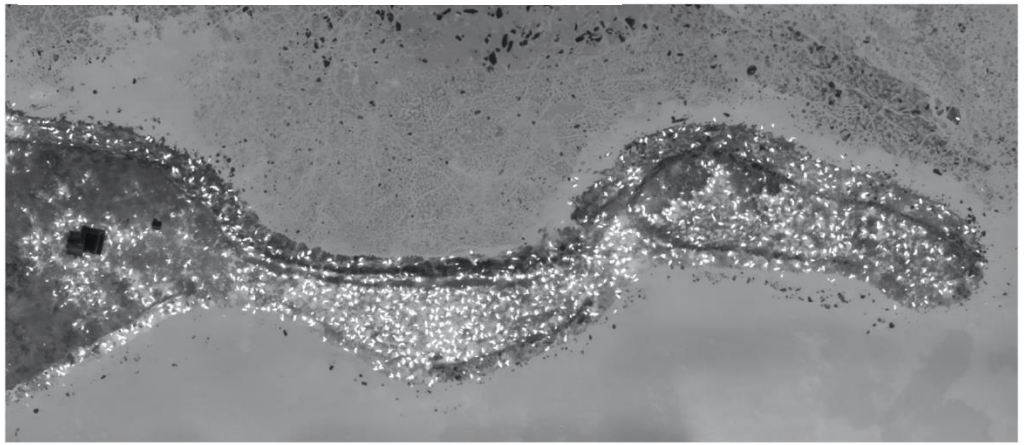
2019

High-ice year



2020

Low-ice year



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Intra- and inter-annual changes in maternal-pup energy transfer

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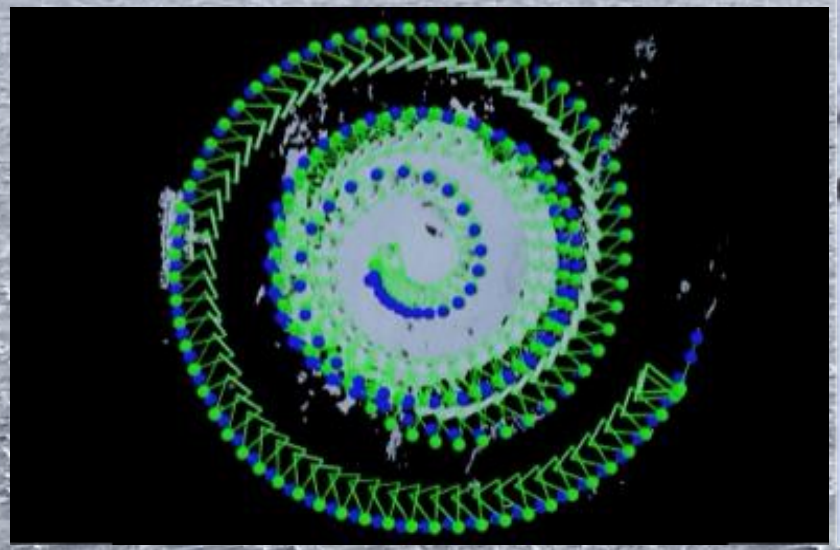
Adaptation for Different Study Systems

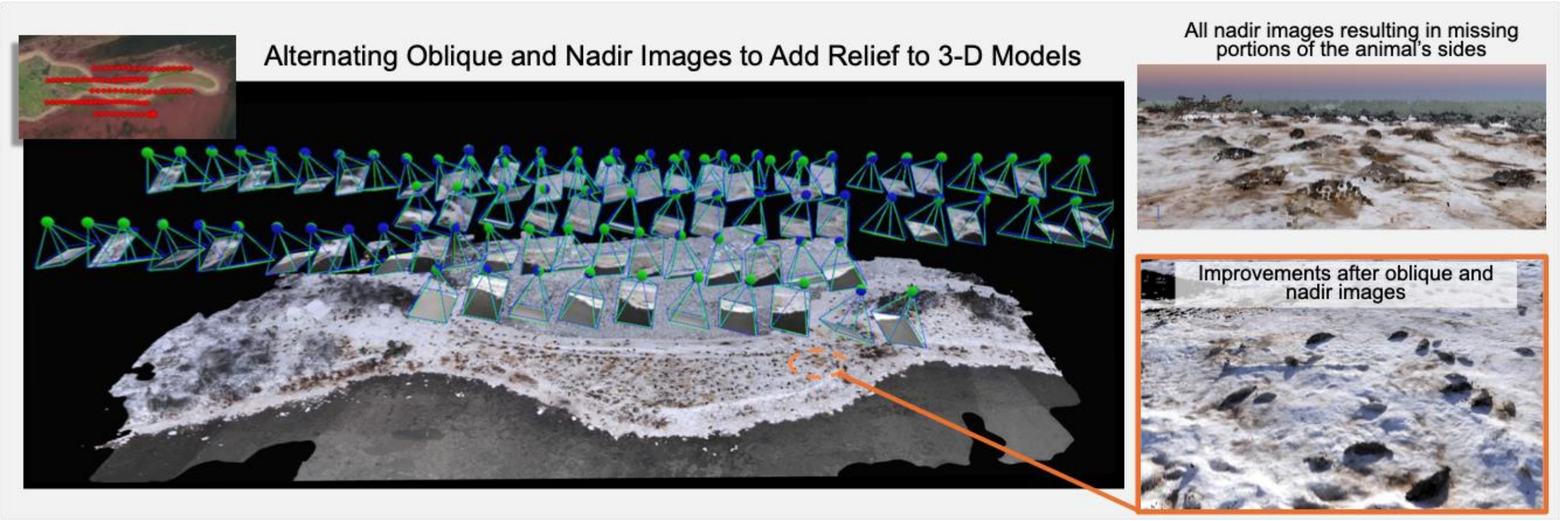
The Ross Sea, Antarctica

- Weather (-30ºC)
- Compass (77ºS latitude)
- Ice !!
  - Homogeneous substrate



NIWA
Taihoro Nukurangi

Adaptation of Flight Plans



Questions?

Conclusions

- Non-invasive means of acquiring indices of energy dynamics. From validation, to application.
- Ultimate goal: wider area ‘health assessments’ within populations. Imagery techniques will facilitate a larger sample size than would ever be possible using traditional methods.
- Widely applicable across species and habitats
  - Animal volume, respiration rate, heart rate are indices used ubiquitously across taxa
  - Can likely be adopted to more sensitive species & in different environments

Acknowledgements
Caroline Rzucidlo (WHOI-MIT)
Erin Curry (Cincinnati Zoo)
Mike Hammill (Canada DFO)
Julian Dale (Duke U.)
David Johnston (Duke U.)
Alex Seymour (NOAA)

NMFS 23273, 22298, DFO Research notice 15-7, ACA permits for Antarctic, IACUCs, FAA 107

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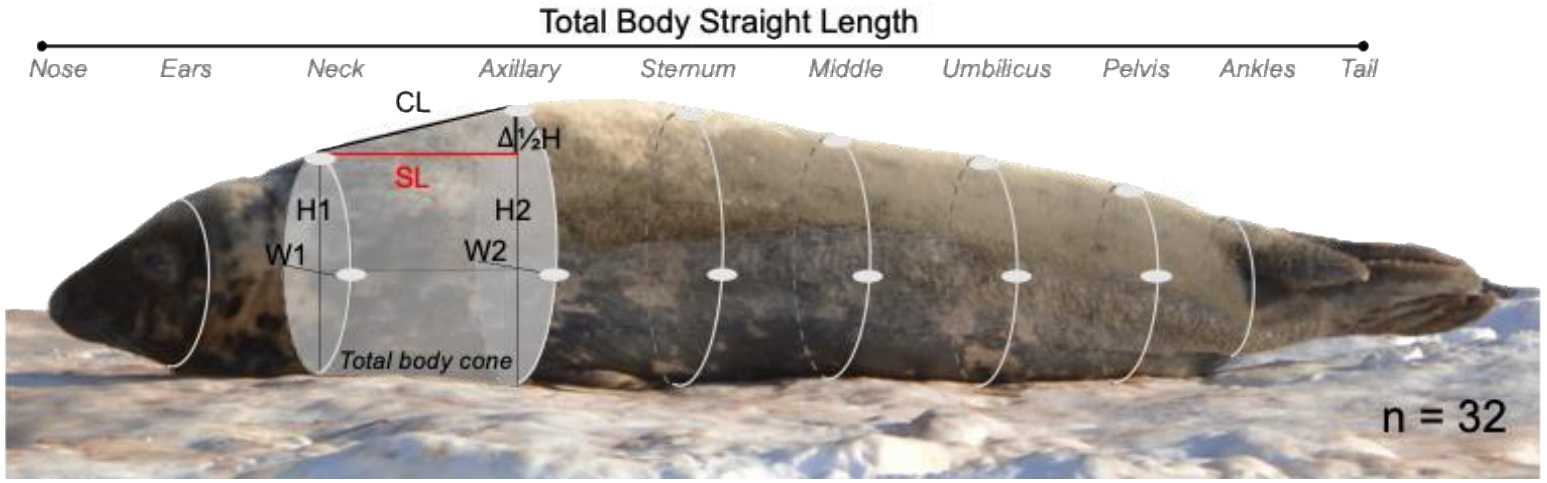
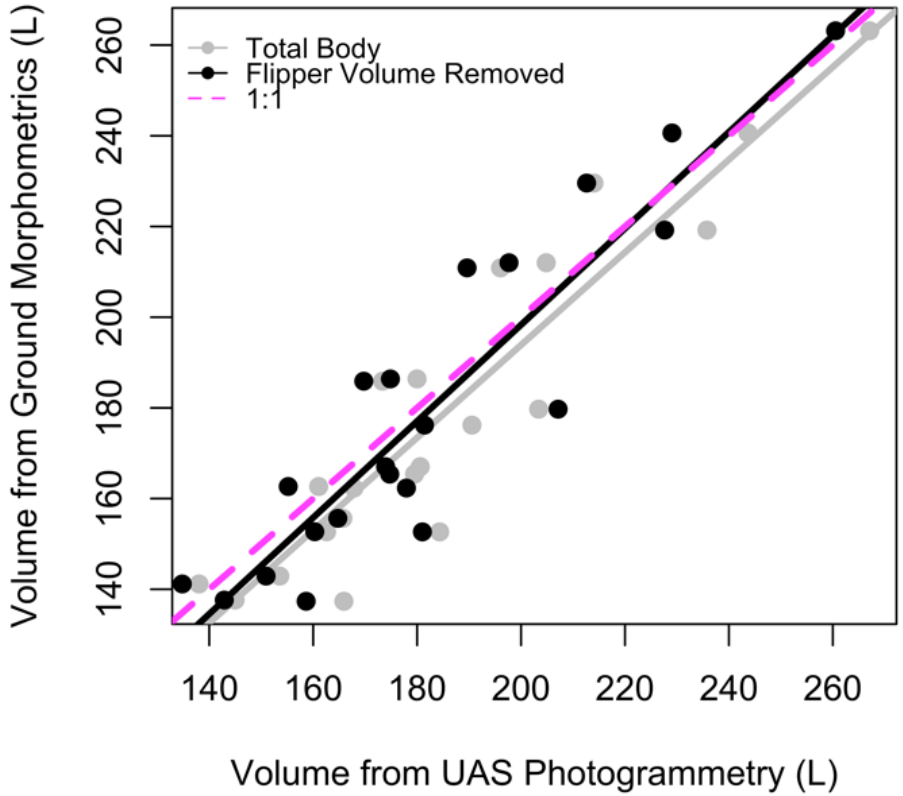
NSF

NATIONAL GEOGRAPHIC

Ground-Truthing





No effect of: Position (sternal v. lateral recumbency), Posture (animals curved v. straight), Terrain (snow, ice, tall grass, dirt), or Flight Characteristics (#Images, Orbit Diameter, Altitude, Ground-Sampling-Distance)

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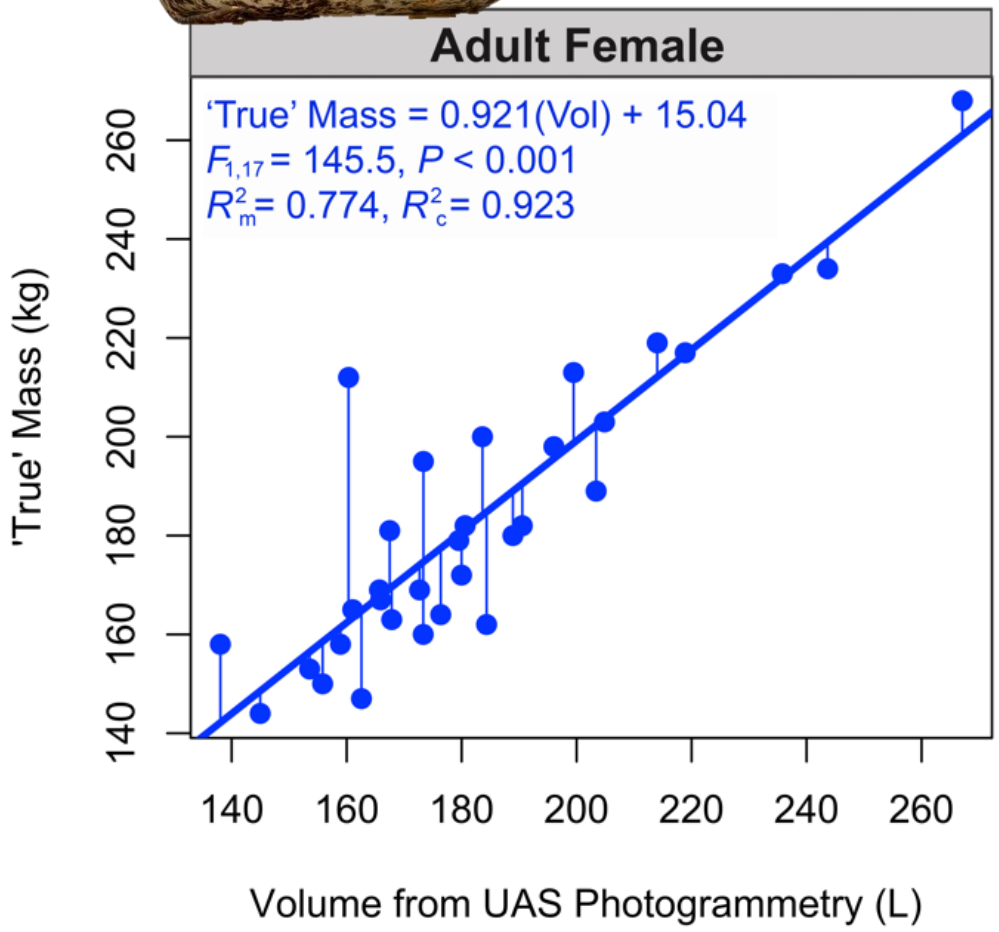
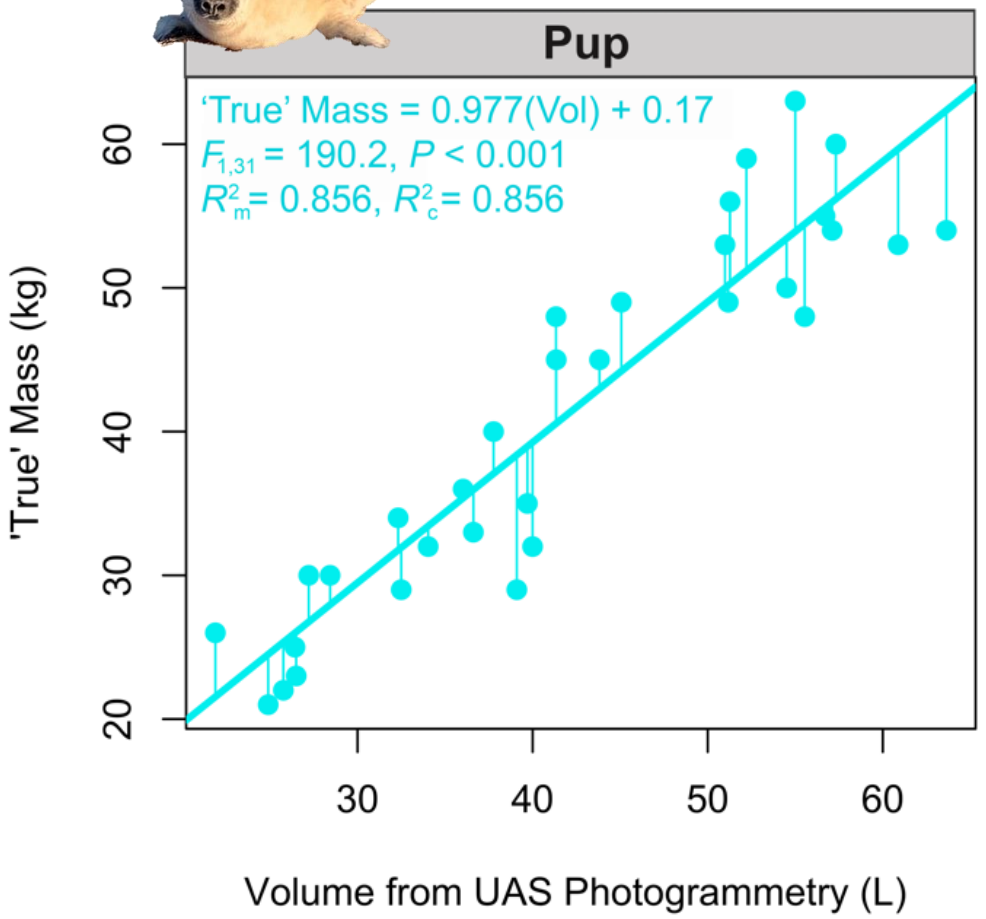
A non-invasive alternative to weighing

MAE: 2.1%



MAE: 9.8%



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