The energetics of moulting southern elephant seals determined by thermal imaging

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FACTS

The moult in most phocid seals is a gradual process and takes around 3 to 4 months except for a few species. Southern elephant seals not only replace their hair but shed their epidermis within approximately a month (Boyd et al. 1993). The epidermal cells of phocid seals require a minimum temperature of 17 °C for growth, which is well above the water temperature experienced by most phocid seals and therefore they must haul-out to moult. Optimal temperature at which epidermal cells proliferate is 37 °C thus maintaining a high skin surface temperature would minimise moult duration. Huddling is a powerful energy saving strategy, widely used by mammals and birds facing high energetic demands (Gilbert et al.2010). The role of huddling as an energy saving strategy for moulting elephant seals has not previously been investigated.

References:
Boyd et al. 1993. Water flux, body composition and metabolic rate during molt in female southern elephant seals. *Pysiological Zoology.* 66(1), 43-60.
Gilbert et al. 2010. One for all and all for one: the energetic benefits of huddling in endotherms. *Biological Rev. 85, 545-569.*

HYPOTHESIS

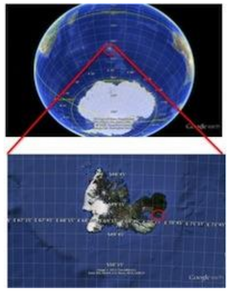
The moult is an energetically costly phase of the lifecycle for southern elephant seals during which seals may aggregate or huddle more or less closely, depending on weather variables, in order to maintain an optimal skin surface temperature for the renewal of their hair and skin.

AIMS OF THE STUDY

- To determine how elephant seals behave during the moulting period (huddling, posture, haul-out sites and changes of location) according to their body size and to weather conditions.
- To examine the extent to which huddling behaviour is an energy saving strategy for elephant seals during the moult by estimating the relative heat loss from moulting seals as the moult progresses.

MATERIAL & METHODS

Study site:
Pointe Suzanne, Kerguelen Archipelago (49°26'S; 70°23'E)



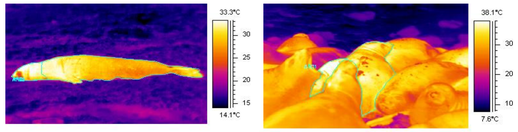
Behavioural data (Group size, Huddling, Position in group):
(a) Individual resights (n=22 followed daily in 2012,
(b) with 8 equipped with GPS data loggers)
(b) Daily transects in three habitats (Beach, Grass, Wallow)
Definitions: Group = within one body length; Huddling = touching

Environmental data:
Fixed automatic weather station
Weather measurements taken with hand-held instruments during resights and transects studies.

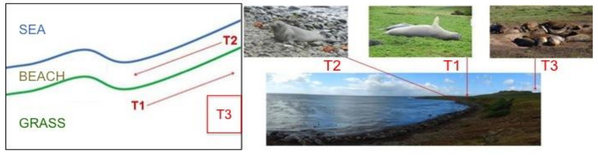
Energetic data:
Stage of moult (0 – 100 %)
Thermal images obtained with infrared camera (Transects & Resights with FLIR P25 Thermacam) were analysed to obtain average and local surface temperature points of seals body-parts (FLIR ThermaCAM Researcher Pro 2.10).
Body mass measured at beginning and end of moult (for individual resights only).

(a) Thermal image analysis methodology for individual resights:

- Average temperatures of the head and the body where determined by delineating the areas visible within the image
- **The difference between mean body surface temperature and air temperature (dT)** was used to examine changes in temperature of animals throughout the study

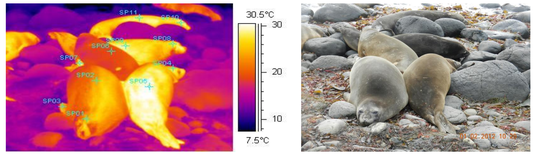


(b) Transect study areas (T1-Grass, T2-Beach, T3-Wallow)

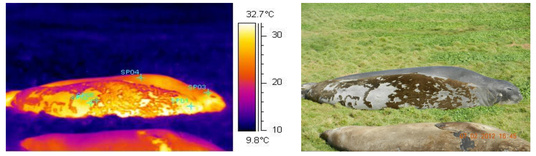


(c) Thermal image analysis methodology for transects:

- Where possible for each individual, 3 temperature points: (1) forehead, (2) one on the back or belly of the seal dependent on position and (3) fore flipper.



- For moulting individuals, 4 temperature points when possible: (1) forehead, (2) hot point (new skin) on the back or belly of the seal dependent on position, (3) cold point (old skin) and (4) fore flipper.



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RESULTS

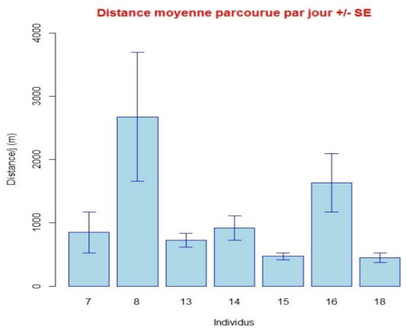
Individual Resights

- Hair renewal is fast (~ 10 days). Starts around extremities: tail, head and flippers, followed by gradual loss of the remainder of the skin.
- Variability in daily mass loss between individuals (Table 1,.

Table 1. Body mass loss during the moult for 11 individuals that were recaptured

		CAPTURE	RECAPTURE			
Seal id	n obs.	Body mass (kg)	Body mass (kg)	n days	Total weight loss (kg)	weight loss/day (kg/d)
8	0	279	245	14	34	2.43
13	14	320	290	11	30	2.73
19	5	291	239	19	52	2.74
12	3	323	281	15	42	2.80
16	10	280	236	15	44	2.93
4	8	308	270	12	38	3.17
7	0	364	299	20	65	3.25
15	7	323	282	12	41	3.42
mean		311	268	14.75	43.25	2.93
Sd.		28.21	24.52	3.28	10.99	0.33

- Variability in movements on land and at sea between individuals. The figure (below) shows the mean distance covered (m/day) for each individual equipped with a GPS logger.



Transects

During the moult, seals use different habitats:
(a) Grass, beginning of the moult (b) Wallow, middle of the moult (c) Beach, end of the moult

Table 2. Summary of GLM model results for the effect of environmental variables on measurement of surface temperature in two different habitats.
(Significance levels, NS, *P<0.01, **P<0.001, ***P<0.0001).

Model Terms	Habitat	Significance level
Relative humidity (%)	Beach	**
	Grass	NS
Wind ($m.s^{-1}$)	Beach	*
	Grass	*
Cloud cover (%)	Beach	NS
	Grass	NS
Solar radiation ($W.m^{-2}$)	Beach	NS
	Grass	***

Table 3. Summary of environmental variables and surface temperature measurements of different body parts for seals hauling-out on the grass and on the beach. Values are given as means ± sd.

									Temperature points (°C)					
	n total	n dry	n moulting	Temperature (°C)	Relative humidity (%)	Wind ($m.s^{-1}$)	Cloud cover (%)	Solar radiation ($W.m^{-2}$)	Head	Back	Belly	Flipper	Moult new skin	Moult old skin
Beach	538	168	4	11.9 ± 2.9	59.8 ± 10.2	4.6 ± 2.0	35.7 ± 22.9	669.8 ± 251.3	28.4 ± 4.2	29.8 ± 3.5	26.7 ± 3.9	28.4 ± 3.2	31.6 ± 3.2	25.2 ± 6.7
Grass	428	291	12	9.8 ± 3.1	62.1 ± 12.2	6.1 ± 1.7	44.2 ± 24.4	553.7 ± 280.7	25.3 ± 4.1	24.9 ± 4.2	23.5 ± 3.6	25.5 ± 4.2	28.4 ± 2.9	22.1 ± 3.1

Summary

- Moult duration is similar between individuals but total body mass loss and movements patterns are different.
- Moulting seals prefer wallows. Seals hauling-out on the grass or on the beach are generally at the beginning or the end of their moult.
- Body surface temperatures of moulting seals are different than from non-moulting seals. New skin has higher temperature than old skin.
- Environmental conditions influence body surface temperatures in different habitats.

What's next?

- Analyses to be continued in order to determine the extent to which huddling behaviour is an energy saving strategy for elephant seals during the moult
- Two more years of data collection: 2013/2014, 2014/2015
- Deployment of ARGOS tags and stomach temperature loggers

Thanks to the Institute Paul Emile Victor (IPEV) and the "Territoire des Terres Australes et Antarctiques Françaises" (TAAFs) for logistic support, Malcolm O'Toole and Christophe Guinet's team (PR109) for help in the field and the Marine Alliance for Science and Technology for Scotland (MASTS-PECRE) and Carnegie Trust for the Universities of Scotland for funding.