WHEN 3% MAY NOT BE 3%;

DEVICE-EQUIPPED SEABIRDS EXPERIENCE VARIABLE FLIGHT CONSTRAINTS

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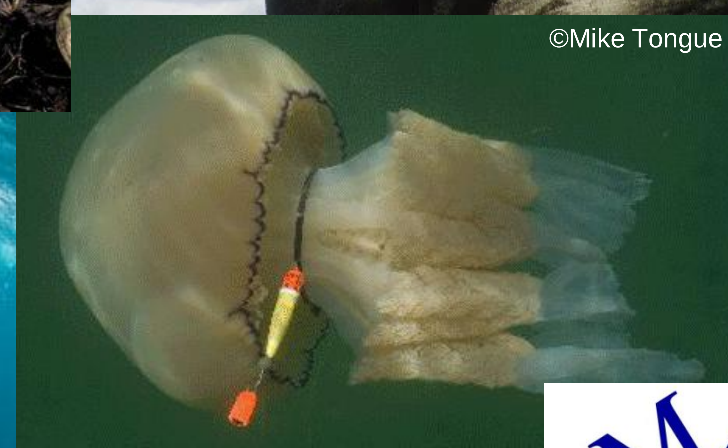
Animal tracking and logging studies



SMART
Swansea Moving Animal Research Team

General bla bla

Potential negative impact of devices

- Aberrant behaviours
  - Eg: device-induced behaviours [a]
  - altered foraging behaviour [b]
- Physical injuries [c]

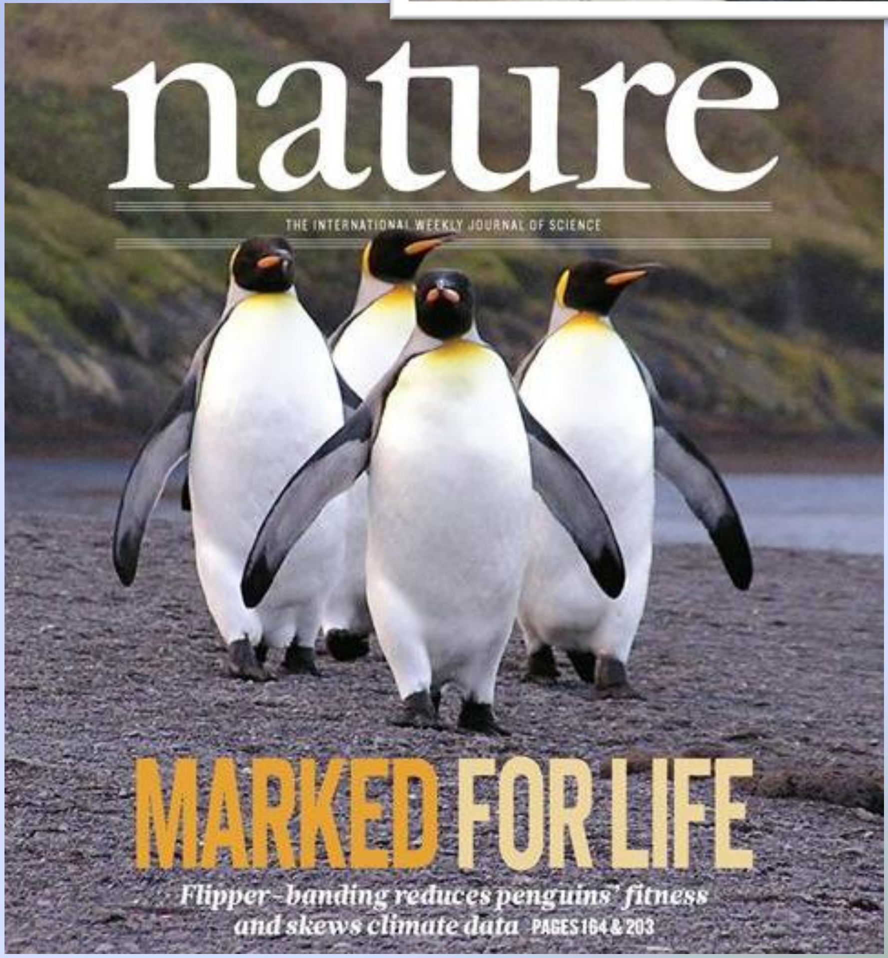
[a] Wilson & Wilson 1989 [b] Phillips et al 2003 [c] Buehler et al 1995

More bla bla

Potential negative impact of devices

- Compromised energetics

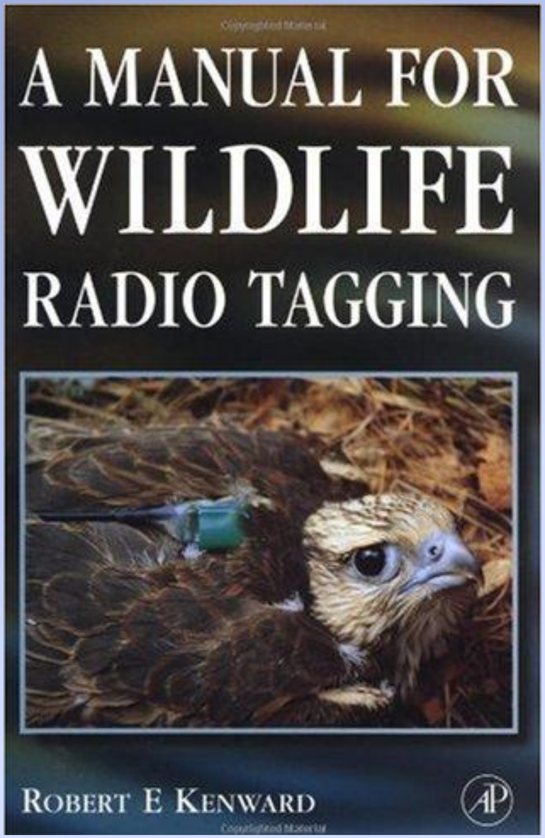
Swimming performance
of penguins



Saraux et al 2011, Nature 2011

What about flying performance ?

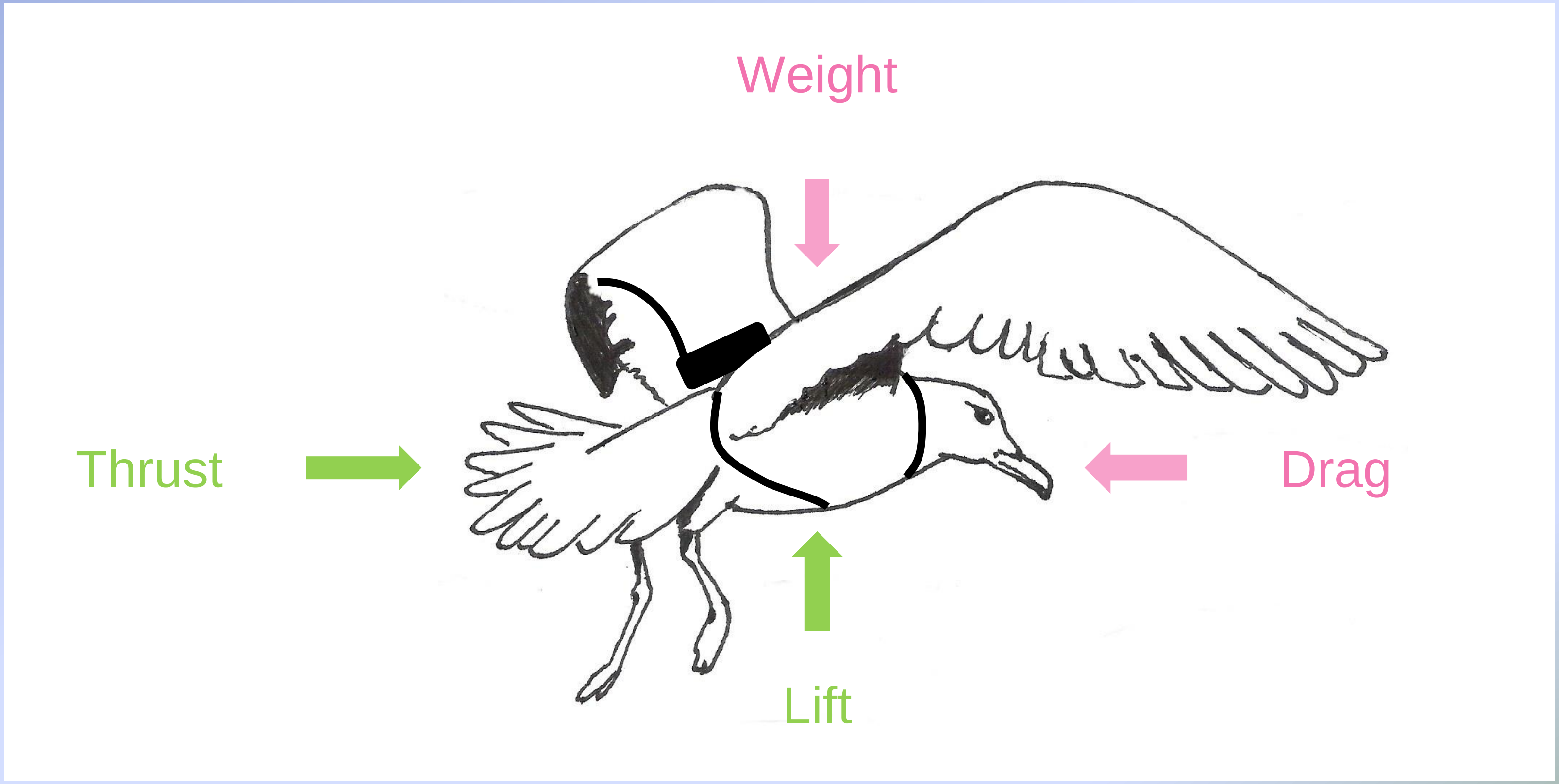
To date – we tend to use the “3% rule” (Kenward 2001)



Objectives

To examine the effects of payload on the energetics of flying seabirds

4 primary forces



How to do it?

Determining birds energetics for flight is hard (impossible?)

Functional Ecology 2004
18, 168–183

ESSAY REVIEW

Measuring metabolic rate in the field: the pros and cons of the doubly labelled water and heart rate methods

P. J. BUTLER,*† J. A. GREEN,* I. L. BOYD‡ and J. R. SPEAKMAN§

The Journal of Experimental Biology 213, 2958-2966

doi:10.1242/jeb.043414

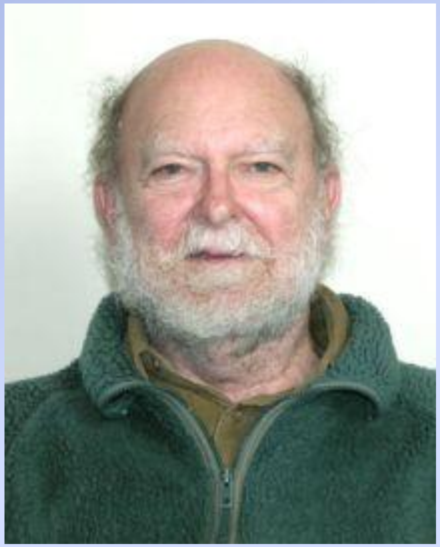
Application of the two-sample doubly labelled water method alters behaviour and affects estimates of energy expenditure in black-legged kittiwakes

Jannik Schultner[1,2,*], Jorg Welcker[1], John R. Speakman[3], Erling S. Nordøy[2] and Geir W. Gabrielsen[1]

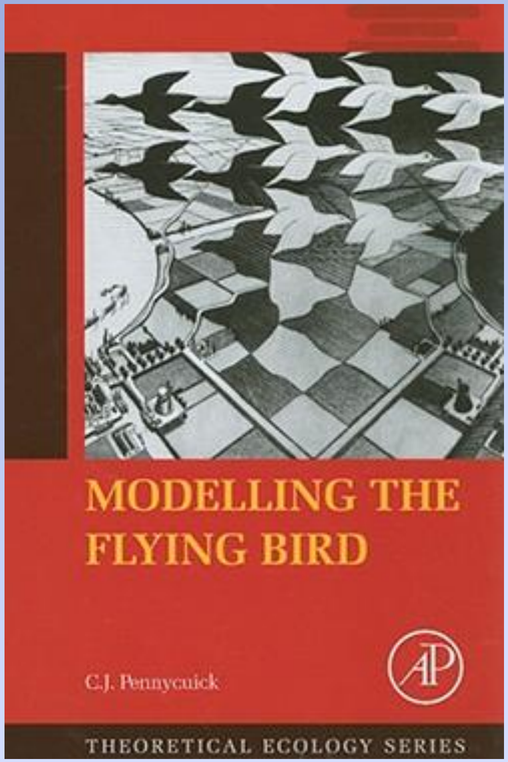
CO_2 production in animals: analysis of potential errors in the doubly labeled water method

KENNETH A. NAGY
Environmental Biology Division, Laboratory of Nuclear Medicine and Radiation Biology, University of California, Los Angeles, Los Angeles, California 90024

How to do it?



Flight program* of Prof. Pennycuick



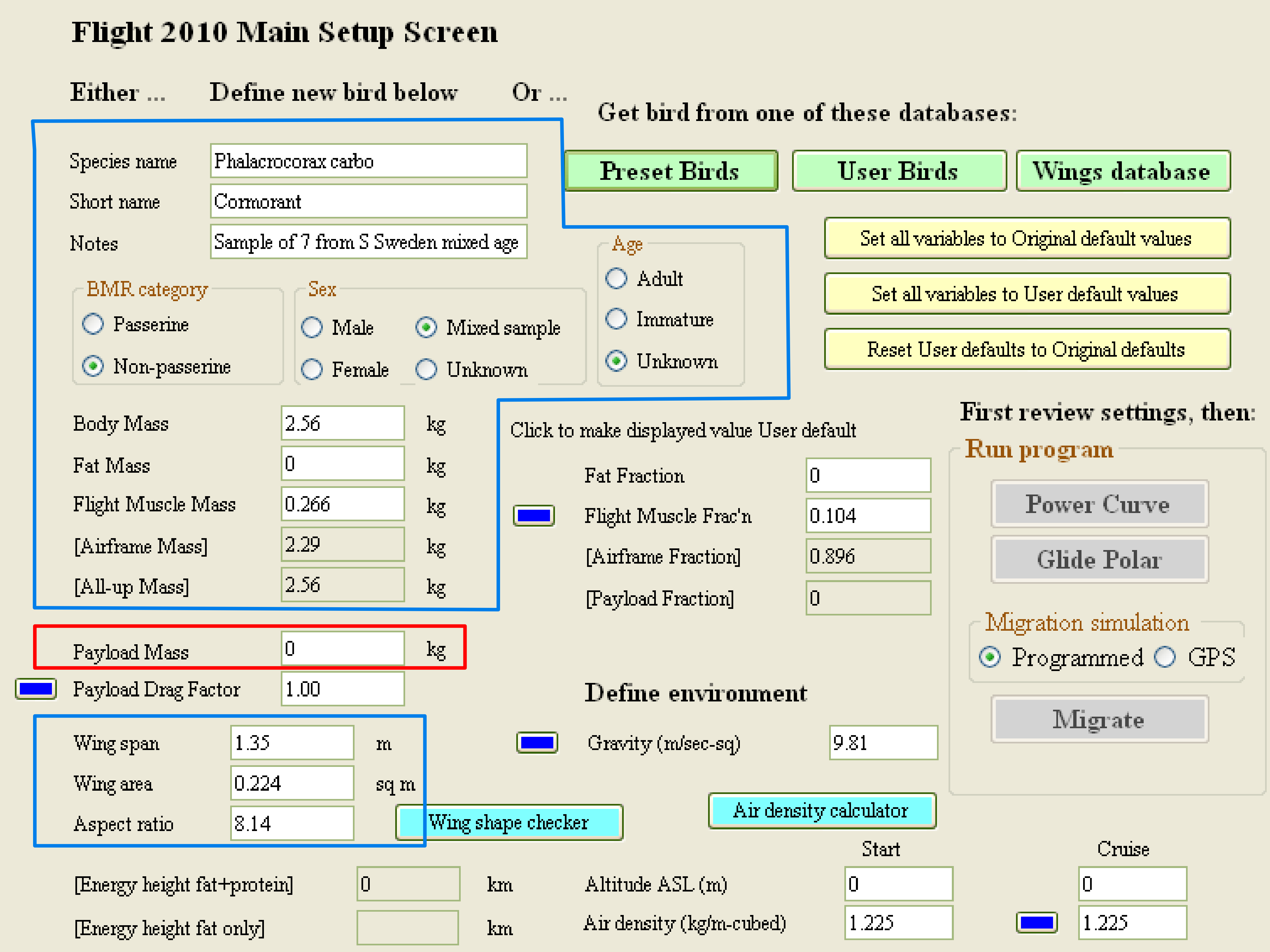
To model flight performance of birds

Based on aerodynamic rules (can be applied to particular birds and situations)

Simulation of payload effect

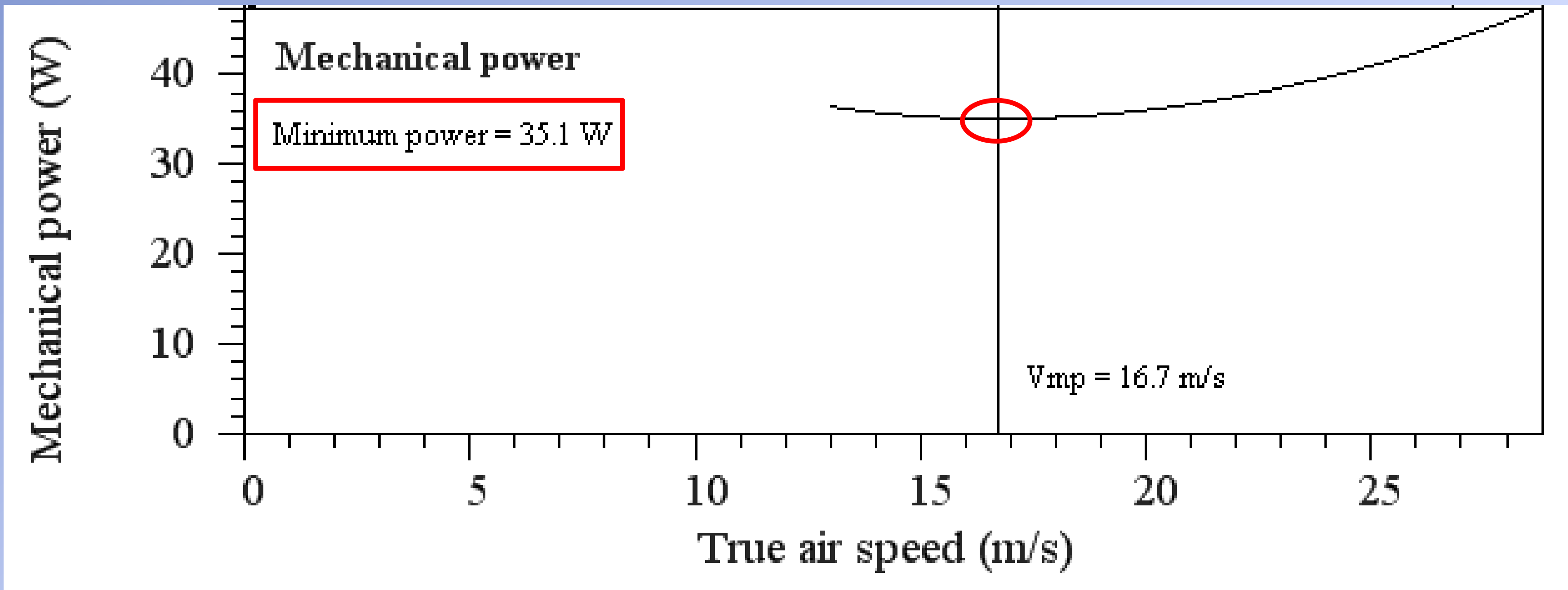
*New version of the freeware available online at http://books.elsevier.com/companions/9780123742995

(1) Devices are a heavy burden!



Flight 2010 Main Setup Screen
Either ...
Define new bird below
Or ...
Get bird from one of these databases:
Species name
Phalacrocorax carbo
Short name
Cormorant
Notes
Sample of 7 from S Sweden mixed age
Preset Birds
User Birds
Wings database
Set all variables to Original default values
Set all variables to User default values
Reset User defaults to Original defaults
BMR category
Passerine
Non-passerine
Sex
Male
Mixed sample
Female
Unknown
Age
Adult
Immature
Unknown
Body Mass
2.56
kg
Fat Mass
0
kg
Flight Muscle Mass
0.266
kg
[Airframe Mass]
2.29
kg
[All-up Mass]
2.56
kg
Click to make displayed value User default
Fat Fraction
0
Flight Muscle Frac'n
0.104
[Airframe Fraction]
0.896
[Payload Fraction]
0
First review settings, then:
Run program
Power Curve
Glide Polar
Migration simulation
Programmed
GPS
Migrate
Payload Mass
0
kg
Payload Drag Factor
1.00
Define environment
Gravity (m/sec-sq)
9.81
Wing span
1.35
m
Wing area
0.224
sq m
Aspect ratio
8.14
Wing shape checker
Air density calculator
Start
Cruise
[Energy height fat+protein]
0
km
[Energy height fat only]
km
Altitude ASL (m)
0
0
Air density (kg/m-cubed)
1.225
1.225

What we look at



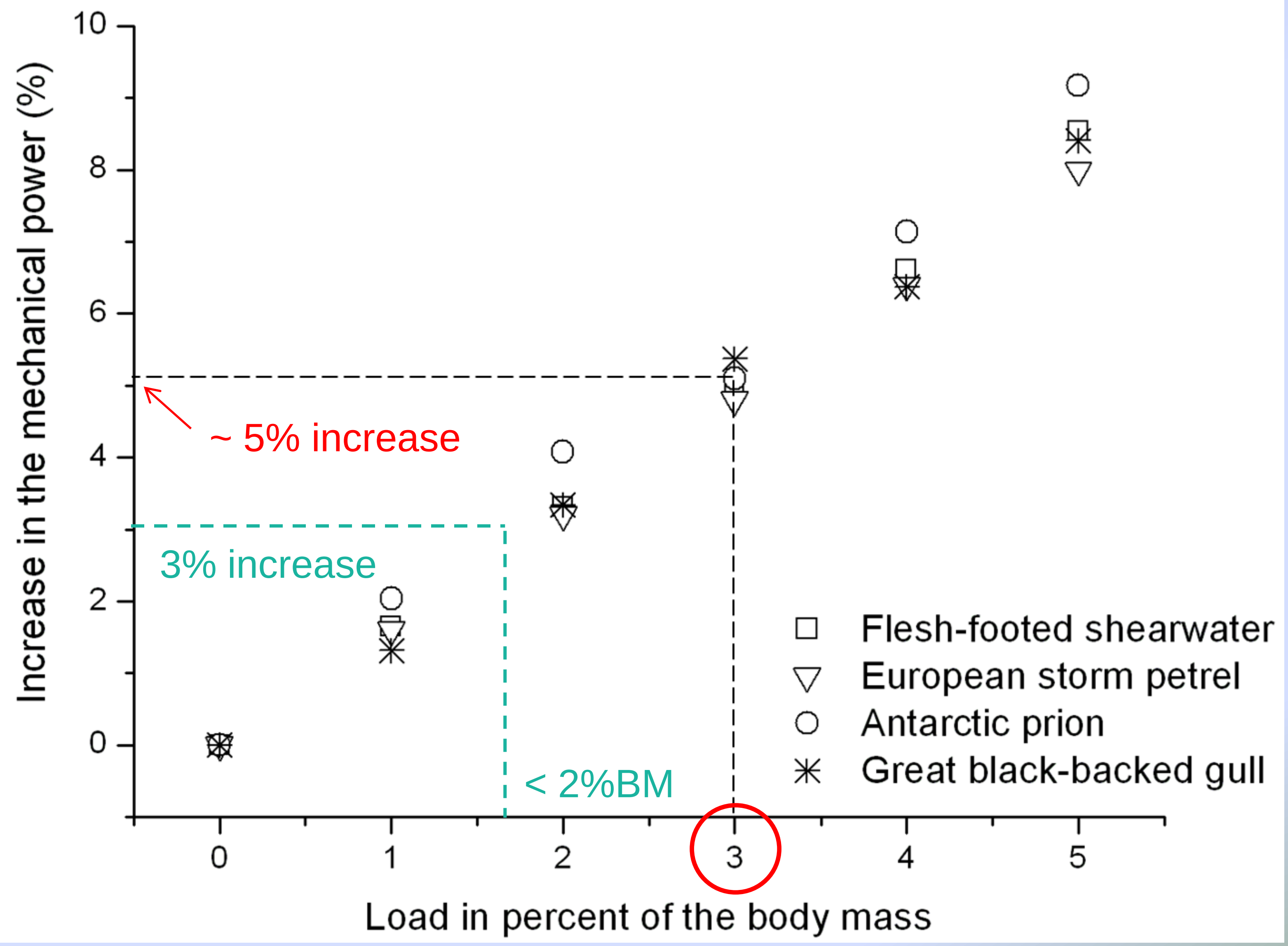
Vmp: The speed for minimum mechanical power

Variation in the mechanical power at Vmp

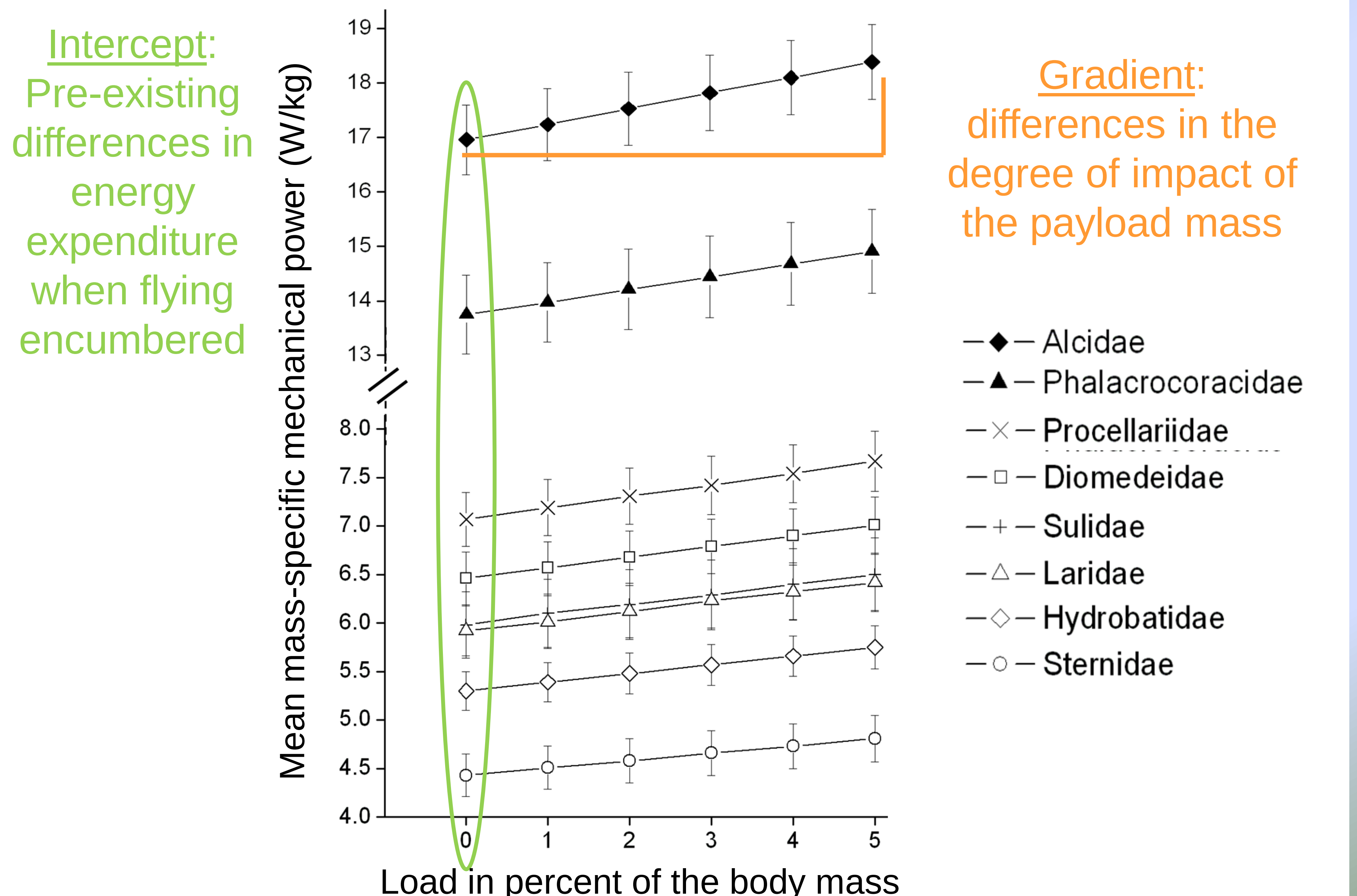
80 seabird species from 8 families

Payload masses from 0 to 5% of the body mass

“3% rule” in terms of energetics



Group – mass-specific power



Interspecies variation

Family	Gradient
Terns (*Sternidae*)	0.07 ± 0.01
Storm-petrels (*Hydrobatidae)*	0.09 ± 0.01
Gulls (*Laridae)*	0.10 ± 0.02
Gannets, boobies (*Sulidae)*	0.10 ± 0.02
Albatrosses (*Diomedeidae)*	0.11 ± 0.01
Fulmarine and gadfly petrels, prions and shearwaters (*Procellariidae)*	0.12 ± 0.01
Cormorants (*Phalacrocoracidae)*	0.23 ± 0.04
Auks (*Alcidae)*	0.29 ± 0.03

Why?

Lifestyles affect morphology e.g. divers vs. non divers


Little Auk (*Alle alle*) © Carsten Egevang


Herring gull (*Larus argentatus*)
© Sylvie Vandenabeele

Heavy body mass
Small wing area

↓

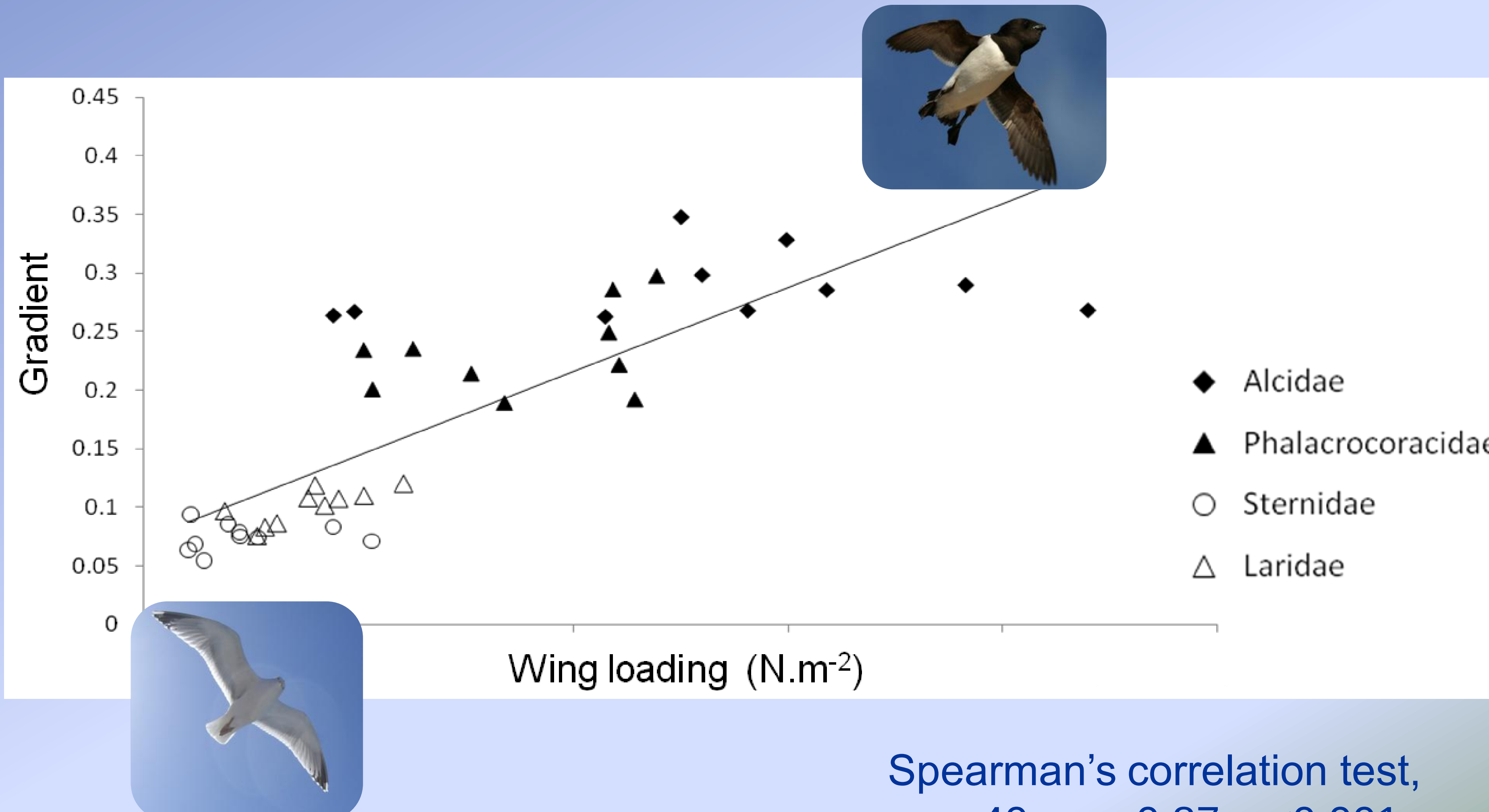
High wing loading

Low body mass
Large wing area

↓

Low wing loading

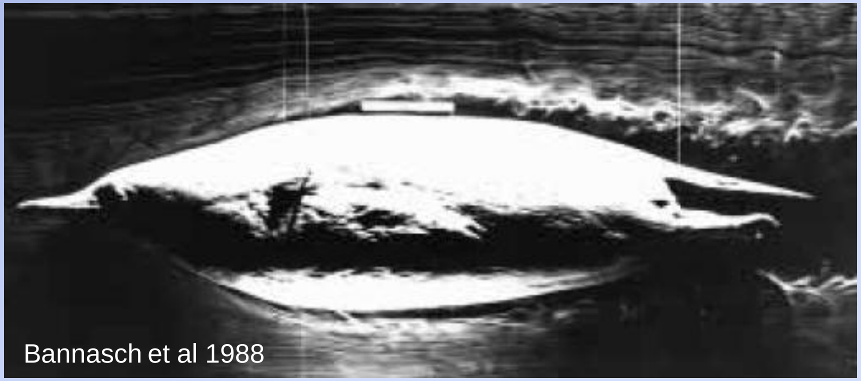
Lifestyles affect morphology e.g. divers vs. non divers



Spearman’s correlation test,
$n = 40$, $rs = 0.87$, $p<0.001$

(2) Devices are a drag!

Drag due to breakdown in natural streamlining

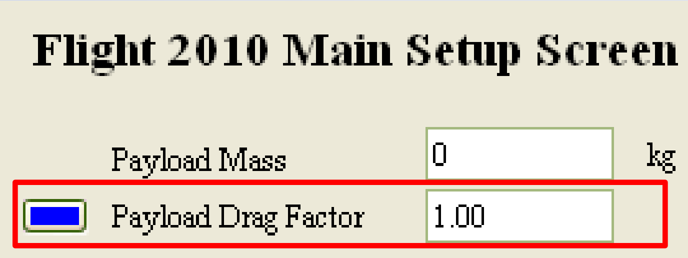

Bannasch et al 1988


Vandenabeele et al (ongoing study)

Simulation drag effect

Drag indices tested with the program

-Perfectly streamlined payload,
payload drag factor= 1

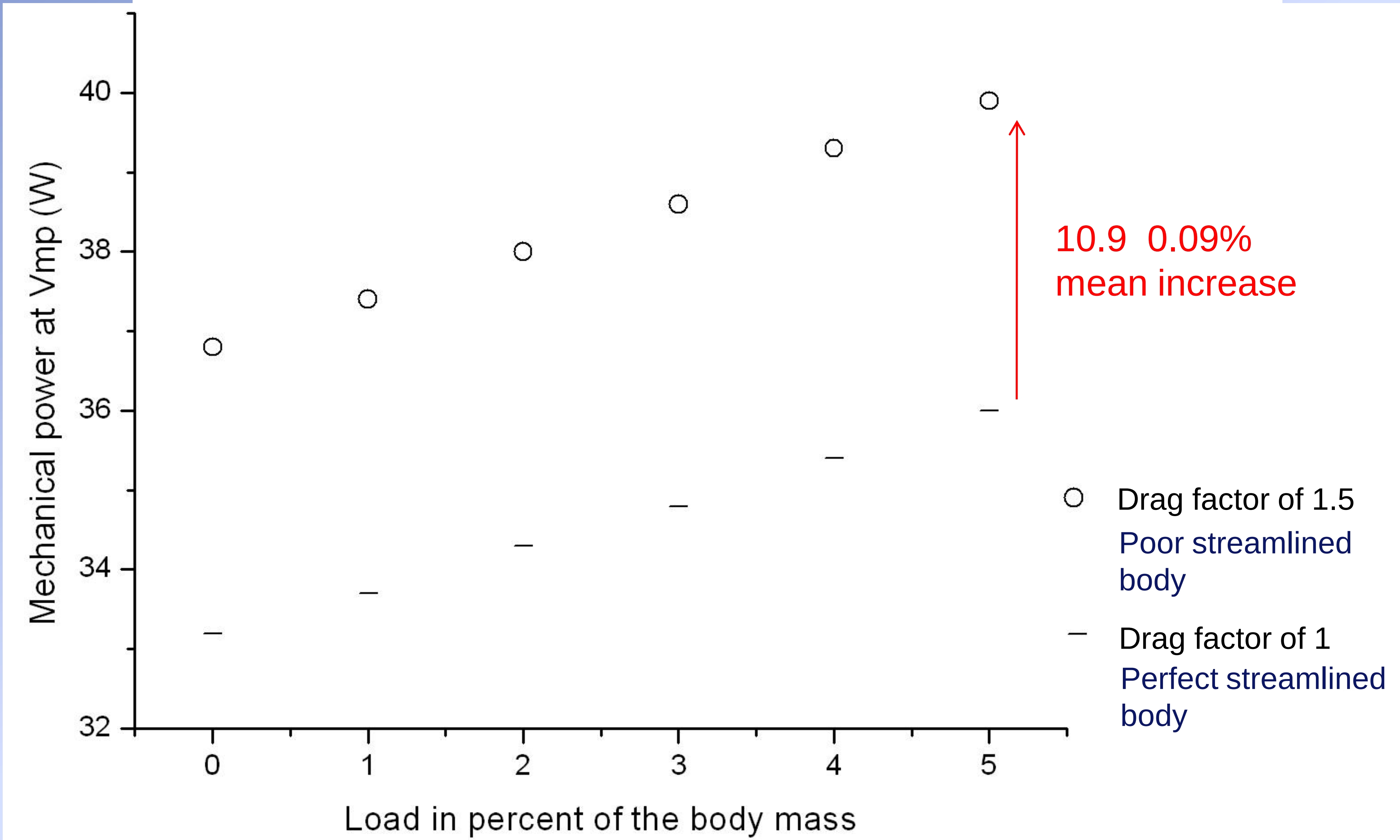


-Example poor streamlined payload,
payload drag factor = 1.5
(drag coefficient of the bird increased by a factor of 1.5*)

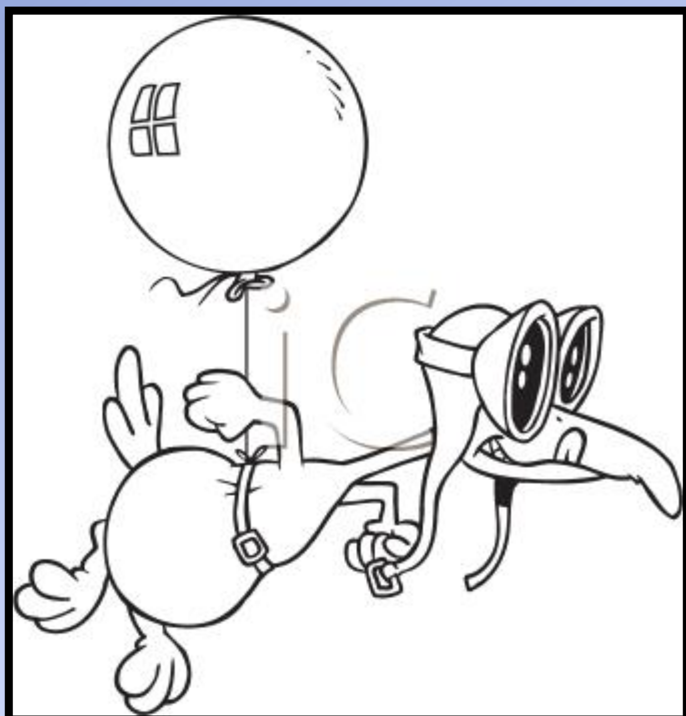
*Factor derived from starling data wearing a ‘device’ measured in a wind tunnel, Pers. Comm. (Pennycuick)

Simulation drag effect

Example of a Great cormorant (*Phalacrocorax carbo*)



Weight and drag are both important



What else?

Behaviour e.g. meal mass!

Chick provisioning period

Mean food load mass of 330g*

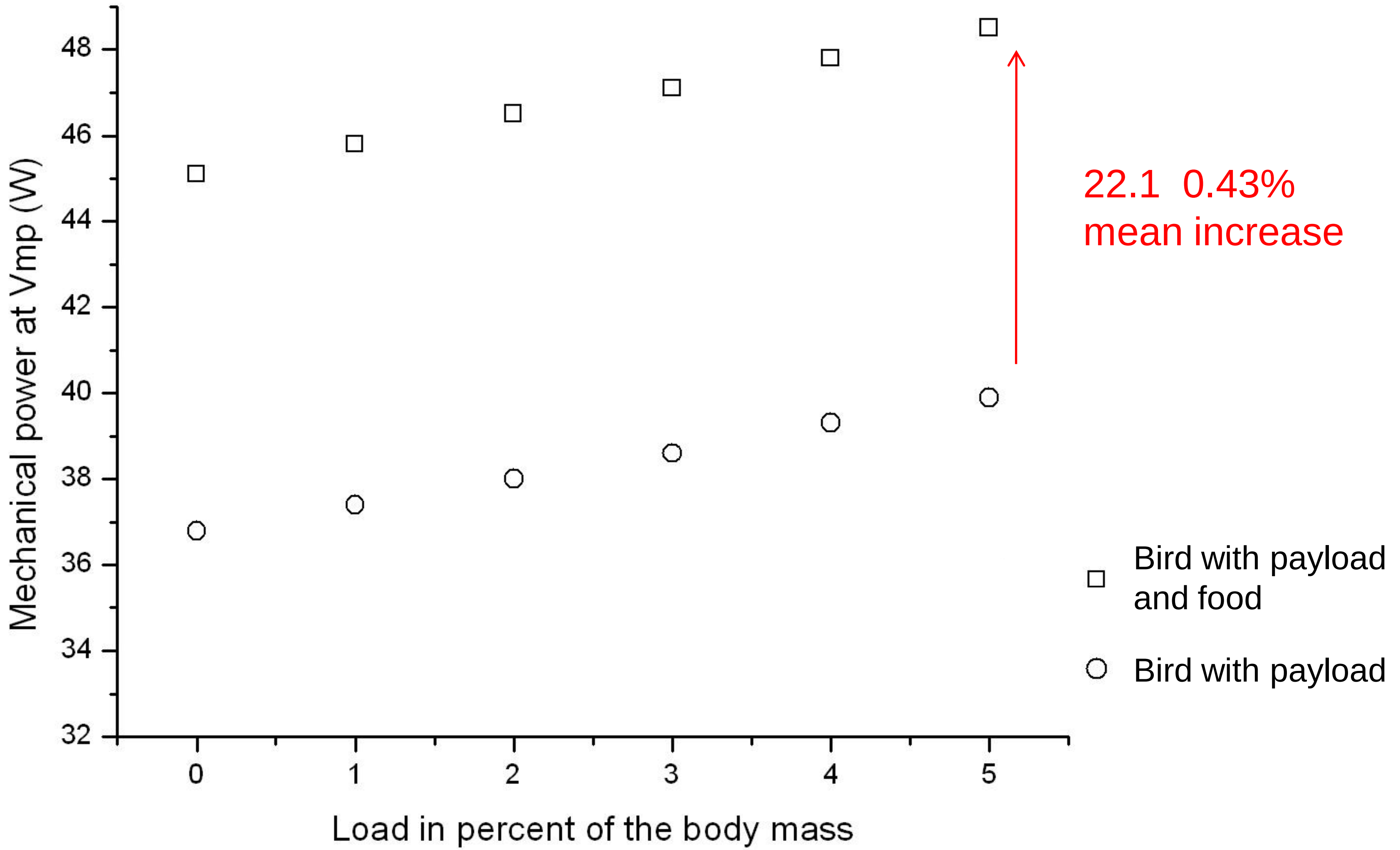
Great cormorant (*Phalacrocorax carbo*) fishing
a fresh trout © Kea Photography

Great cormorant (*Phalacrocorax carbo*)
feeding a chick © age fotostock / SuperStock

* Derived from data of Grémillet et al 1996

Simulation with payload AND food

Example of a Great cormorant (*Phalacrocorax carbo*)



Behaviour e.g. flight duration

Phalacrocoracidae family
2 similar species:

	Great cormorant (*Phalacrocorax carbo*)	European shag (*Phalacrocorax* aristotelis)
Body mass (kg)	2.53	1.75
Wing area (m^2)	0.22	0.16
Wing loading (kg/m^2)	11.7	11.2
Mass-specific mechanical power with a 3% payload (J/s)	22.1	19.9

BUT NOT THE SAME BEHAVIOUR !

Flight duration differs

Variance between 'similar' species

Great cormorant

European shag

Outward non-stop flight duration = 10.4 min [a]

Average work done = 23.1 kJ

Outward non-stop flight duration = 4.0 min [a]

Average work done = 10.5 kJ

~ 110% higher!

[a] Grémillet et al 1996

Variance between 'similar' species

Balearic shearwater
(*Puffinus mauretanicus*)

Average flight duration
~ 7 h/day[a]

Sooty shearwater
(*Puffinus griseus*)

Average flight duration
~ 50min[b]

[a] Aguilar et al 2003 [b] Shaffer et al 2009

Flight program application(s)

We can calculate the total energy used in transporting a device for any 24 h period;

Flight time X cost of flight (with device)
+
costs of other activities

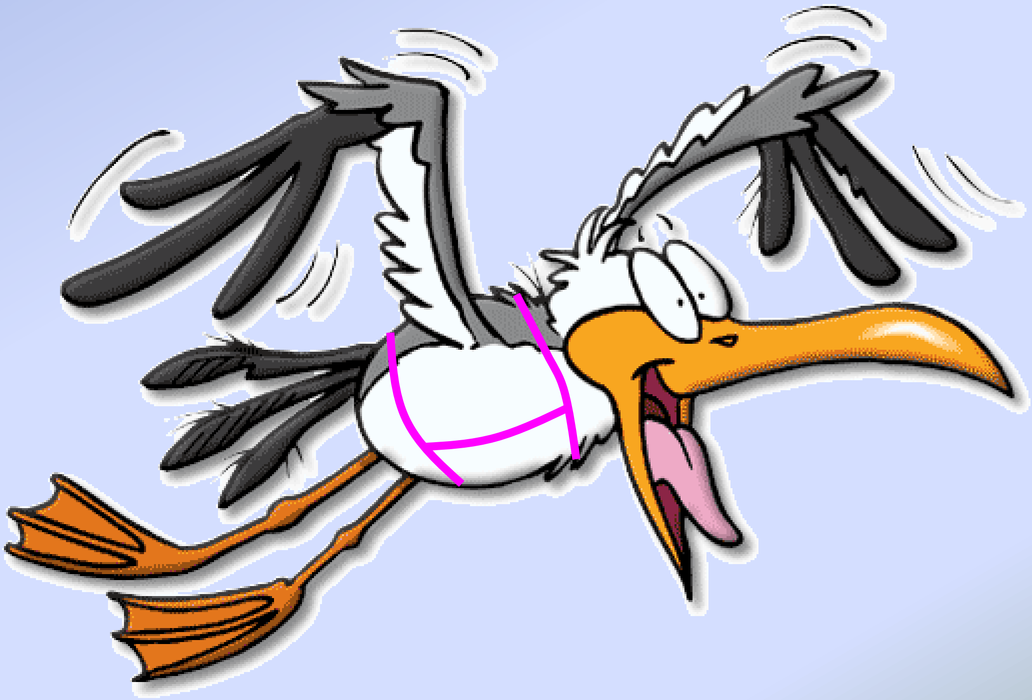
Compare to

Flight time X cost of flight (with no device)
+
costs of other activities

Conclusion

Tags: ARE a revolutionary way to study free-living birds

BUT We need to get smarter about defining device effects (Colin Pennycuick can help!)



Thank you, merci, gracias, danke, arigatō…

Swansea University
Prifysgol Abertawe

SMART
Swansea Moving Animal Research Team

UFAW
Established 1926

RSPCA

Oiled Wildlife Care Network
UC Davis Wildlife Health Center